THE MONTHLY

MAP

VOL. LIV NO. 507

MEASURING THE MOUNTAINS OF THE MOON (Page 4)

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SEPTEMBER • OCTOBER

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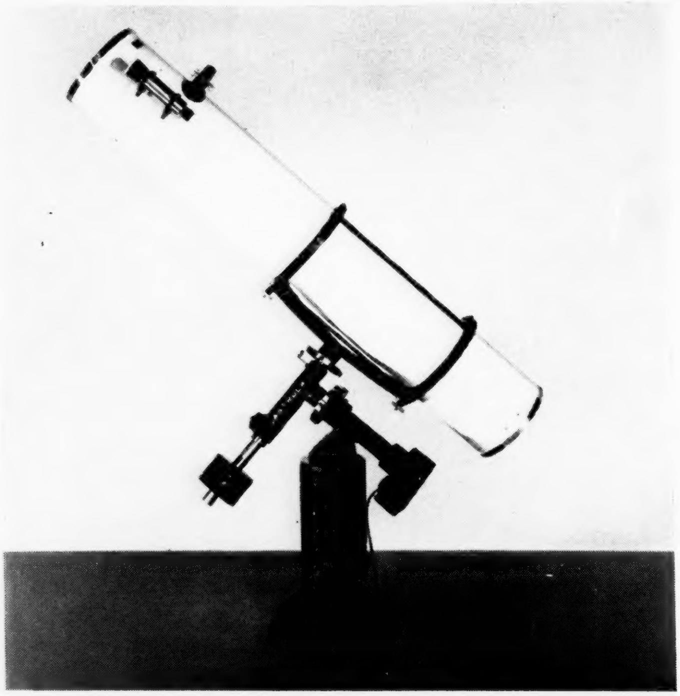

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THE MONTHLY EVENING SKY MAP

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THE MONTHLY EVENING SKY MAP

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CONTENTS

COVER PHOTO

The crater Aristillus (above) and lunar peak Piton (center) dominate this section of a negative made with the 36-inch refractor of the Lick Observatory. Man's moon-mapping is discussed in detail in this issue's feature, "Scaling the Lunar Heights."

DO THE "EYES" HAVE IT?

The stars provide some interesting tests of eyesight. They afford excellent checks, not only of resolving power, but also of sensitivity to faint light.

The classic test, but hardly a real one any more (proper motion of the two optically related stars has widened the separation since the days of the ancient Arabs), are the stars Mizar and Alcor. The two components form the second star from the end of the Big Dipper's handle. Some people find they can see them better when there is a little moonlight. The separation of Mizar (2nd mag.) and Alcor (3rd mag.) is nearly 15′ of arc, which would make it easy were it not for the brightness of Mizar. Mizar is also a telescopic double, with a 4th mag. companion at about 12″ of arc.

A bit harder, but still well within the reach of normal eyes, is Alpha Capricorni. Alpha^1 is magnitude 4.5, Alpha^2 3.8, and the separation is a bit more than 6′ of arc—twice as far apart as the usual limit of resolution of an exceptional eye.

A test that many will flunk is the close pair Epsilon^1 and Epsilon^2 Lyrae (see p. 14), with a separation of 3.5′ of arc. If you plan to try this one on a group, you might take a furtive peek with binoculars first to determine the orientation of the line the two stars make in the sky. Otherwise it is difficult to tell if the observers are actually seeing both stars. Sneaky, perhaps; but discretion is the better part of valor!

In testing sensitivity to faint light, you must realize that such tests are not definitive if there is moonlight, haze, twilight or high, thin clouds. An easy test is Messier 31, the great Andromeda nebula (see p. 14). This is so bright that it can be seen under partial moonlight. On fine, dark nights it can be traced to a length of about 3°—a long, narrow spindle in the sky with a much brighter knot at the center. Close by, between Cassiopeia and Perseus, lies another easy object, the Double Cluster of Perseus.

The real test is, of course, the broadside spiral galaxy M33 in Triangulum. Marked on the equatorial map in this magazine as a small cross just west of Triangulum, M33 requires excellent sky conditions and a sensitive eye. Its faintness (7th magnitude) suggests that it can never be seen by the naked eye, but many observers record it regularly. Actually, the statement that the naked eye can see only to the 6th magnitude is one of those myths that still persist. The actual record is 8.6, made by Dr. Heber D. Curtis at Lick Observatory many years ago. In good skies the normal eye will often reach below 7th magnitude.

One more celestial object, the fabled Pleiades, is a test both of resolution and sensitivity. Five stars are easy, six stars are good; under optimum conditions as many as 8 or 10 can be recognized. The record, as far as this writer knows, is 18, made in 1935 at Tucson, Arizona.

WALTER SCOTT HOUSTON

The staff of the SKY MAP has been encouraged by the many notes of approval which have come to us from individuals, clubs, professional astronomers, observatories and planetariums. Readers can play a part in making the SKY MAP the amateur's own magazine by showing it to friends and suggesting that they subscribe. Each new subscription adds to the extra columns of information we can bring to you—and there is so much to talk about.

SCALING THE LUNAR HEIGHTS

By Thomas Rackham

Although Mr. Rackham's base of operations is the University of Manchester in England, where he works under Dr. Zdenek Kopal, his lunar map project carries him from the French Pyrenees to the United States. A Fellow of the Royal Astronomical Society, Mr. Rackham is also Secretary of the Lunar Section of the British Astronomical Association. He has recently written a book, "Astronomical Photography at the Telescope," *published by Macmillan.*

The earth has orbited the sun about two-and-a-half thousand times since Thales of Miletus demonstrated to an astonished Egyptian king the potentialities of the shadow method as applied to the problems of measuring the heights of inaccessible points above the surface of the earth. By so doing Thales was merely applying the principle of similar triangles in a practical manner to compute the height of the Great Pyramid of Cheops.

To this end he assumed that the sun was set at a great distance from the earth, so that its light rays could be considered parallel to one another. He then reasoned that, if the length of a shadow, falling on level ground as cast from a vertical staff, bore a certain relationship to the height of the staff, then the same relationship held between the length of the shadow of the Pyramid and its vertical height. Thales had to make certain corrections to the measured length of the Pyramid shadow in order to ensure that it commenced from a point on the ground vertically below the apex of the Pyramid, and then, by a simple proportion sum, he was able to announce the height of the Great Pyramid.

Historians tell us that the king was amazed at this feat, but perhaps even greater amazement would have manifested itself upon the erudite features of Thales had he anticipated that, thousands of years later, astronomers would be using his method for the measurement of the inaccessible —and in his time even unknown— mountains and craters of the moon!

Let us look a little more closely at the problem. First of all we must decide what factors Thales knew and what factors remained to be discovered. What was Thales really doing when he performed this simple but impressive experiment? By placing a

In this view along the terminator of the moon, the lunar peak Piton is prominent at left. Its long shadow gives viewers the impression that this mountain is high and jagged and that it rises high above the lunar terrain from a narrow base. Modern measurements have disproved this, British astronomer Rackham explains, as they have for the rim contours of the crater Aristillus (several inches above Piton in the photograph). For Rackham's profile studies of these lunar features, see p. 7. Photo centers on western edge of Mare Imbrium; crater Cassini lies at terminator to left of Piton, crater Autolycus above Aristillus.

Lick Observatory Photograph

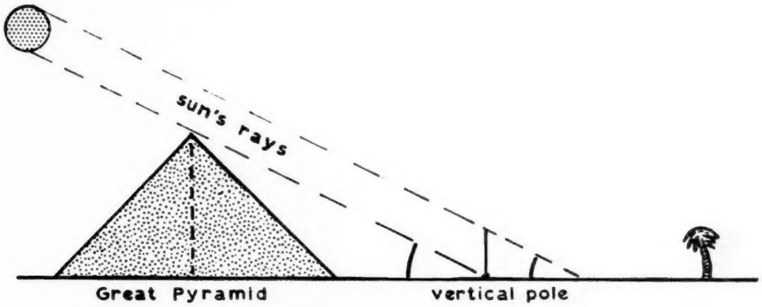
staff vertically with the ground he was providing himself with a triangle consisting of two sides, the staff itself and the shadow of the staff, and one angle—in this case an angle of 90° made at the base of the staff with the level ground. The opposite angle of the triangle at the tip of the shadow would have been the angle of the sun's inclination at this point, and the hypotenuse (side opposite right angle) of the triangle would have been the path of a ray of light from the sun across the top of the staff to the shadow tip on the ground. In other words, Thales had a solution to his triangle through which he could have found the values of all the angles and the lengths of all three sides, had he so desired.

Now, all this is very easy to do on the earth, but the moon (at the time of going to press!) is still an inaccessible object and the problem of erecting a vertical staff on its surface is still a matter of considerable difficulty and futility, since such an object would be invisible in our largest telescopes. Therefore, while the problem is essentially identical with that of Thales, we must attack it from a different direction.

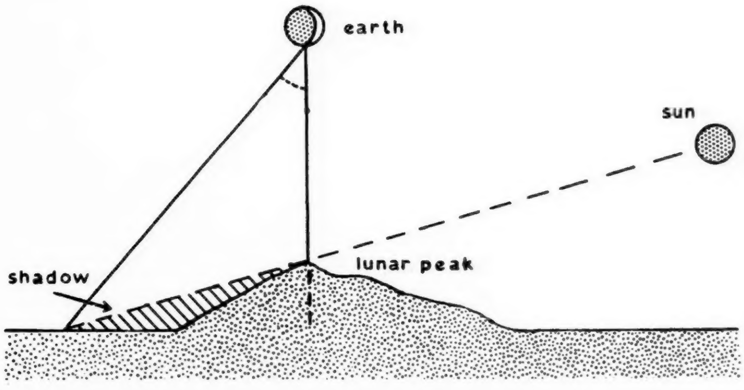
As before, we are trying to find the solution of a right-angled triangle: we have already the measured length of a shadow cast across the surface of the moon by a lunar mountain peak, and we assume also that the shadow starts from a point vertically *below* the peak, so that we have a right angle. Now, in order to complete the triangle we have either to know another side *or* another angle and, since the *vertical* side is in fact the height we wish to measure, we must attempt to find the angle at the tip of the shadow. In other words, we need to know the value of the angle of inclination of the sun from the peak in question. Once we know this angle we can find the height of the peak above the point on the lunar surface occupied by the shadow tip. We must emphasize that we are obtaining *relative* heights only, for, as yet, there is no way in which we can refer to a "mean moon level," and, before we can know this, we have to find the shape of the moon, a very difficult problem which has defied selenographers for many years.

Fortunately for us all the data we need to compute the necessary angles is to be found in the Nautical Almanac, but if we desire utmost accuracy we must make allowances for many factors. First of all we must know, to a few seconds, the time that the lunar negative was exposed, and from this we can derive all the photographic constants. At this instant the lunar *librations*—which are the shakings and noddings of the moon that enable us to see a little more than half of the lunar surface, and which are caused by the eccentricity of the lunar orbit as governed by Kepler's Laws—can be determined accurately, for these will certainly influence the lengths of the lunar shadows. Likewise, the same eccentricity of the lunar orbit causes the moon to approach and recede from the earth, and this changes the *scale* of the lunar image as recorded in the telescope. This too must be corrected. The *position* of the *observer* on the surface of the earth also has a marked effect on shadow lengths, for a telescope, say 40° west of the meridian, will show a different aspect to one placed as many degrees east of the meridian. These are some of the factors that influence our calculations.

As well as these we need to know as accurately as possible the actual position of the peak on the moon in terms of orthogonal lunar coordinates, i.e. the x, y, positions taken from a grid ruled in equal intervals



(TOP) Thales used the "proportional triangle" method to measure the height of the Great Pyramid. Angle made by sun with top of Pyramid and pole was the same. By adding half of base to length of shadow cast by Pyramid, Thales had two sides and two angles. Using these he worked out the simple proportion and obtained the Pyramid's height.



(BOTTOM) Assuming that shadow begins at point under peak, astronomers can measure length of shadow and determine angle of illumination of sun's rays on lunar surface, thus allowing them to calculate mountain height by simple trigonometry. "Height above what?" is a problem; moon has no water and therefore no "sea level."

over the apparent "flat" lunar disk; or alternatively, in terms of lunar longitudes and latitudes, where the lines of longitude converge towards the lunar "poles" like their terrestial counterparts. Since the moon is a globe, the accuracy of such coordinate systems is best at the center of the moon as seen from the earth, and it becomes increasingly more difficult to state with precision the position of a point on the lunar surface as we approach the limb regions, and this introduces additional errors in the computed heights of lunar mountains. Fortunately there are other methods that can be used very effectively in these areas to achieve accurate results.

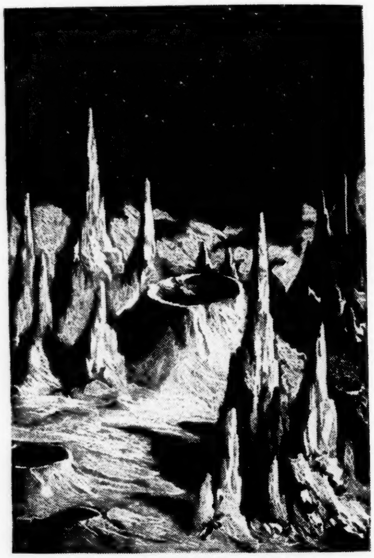
I will not bore the reader with other details connected with the calculations of lunar heights using the shadow method, but I think that I have written enough to show that the computations are somewhat more involved than those of Thales, and they do take some considerable time to work out on desk calculating machines. However, now that we live in the age of electronics we are able to make use of the latest electronic computing machines, and these are programmed so as to produce from the data that are put into them the heights of lunar mountains. The accuracy of these machines is superior to the human calculator sitting at his desk, and the speed is such that a machine will produce in a few seconds results that the human operator may take many hours to compute.

This reproduction of a drawing from Ball's "Stargazing" shows central peak within Copernicus being measured with a filar micrometer. Measurement of lunar photographs has largely replaced this method.

From the point of view of the actual measurement of the lunar shadows there are two main lines of approach. Firstly—and many of the early selenographers used this method—there is the *direct measurement* of the lunar shadow with a micrometer used in conjunction with the eyepiece on the astronomical telescope. The observer makes a number of measures visually with the micrometer and takes the mean of these measures as the length of the shadow. This has the advantage of eliminating errors introduced by photography, but, on the other hand, such work is very tiring and laborious to the astronomer, and it is far better to use the all too rare periods of superior telescopic seeing for procuring excellent *photographs* of the shadows, from which measures can be made more conveniently and accurately later on.

For nearly two years astronomers from the University of Manchester in England have been going up to the Pic-du-Midi Observatory in the French Pyrenees in order to photograph the moon with the 24-inch refractor, and they have succeeded in obtaining many thousands of photographs during the periods of excellent conditions that sometimes prevail at this altitude (9,400 feet). After processing, the negatives are studied and the best ones are selected for shadow measurement. Shadows can be measured by direct optical means on some form of traveling microscope, but, at Manchester, we prefer to use an electronic microdensitometer that traces, on a greatly enlarged scale, the length of the shadow under scrutiny. Several such measures are made of the same shadow on different negatives and, from these, we can deduce the errors owing to atmospheric turbulence. The photographic errors over the length of any given shadow are usually small and, in most cases, can be ignored.

Now what do the results of our researches show? Well, apart from the precise values of the lunar heights that have so far been measured, there are other techniques that give results indicating that the moon generally possesses a flat and undramatic landscape. Even isolated mountains like Piton in the Mare Imbrium, which have been depicted as spire-like "Matterhorns" by numerous artists, have profiles more like upturned saucers, and these results are in accord with those of other astronomers who have studied, by direct means, the profiles of formations around the limbs of the moon. This, then, is a general picture of the larger formations, but this does not mean that all formations are alike and that there will not be exceptions to such rules. Some of the smaller craters, for example, are very much deeper than their diameters would suggest—a section through a large crater like Aristillus would give a shape something like a section through a tea-plate,



Nineteenth century artist's conception of lunar terrain has carried into 20th century. None of the larger lunar features has the jagged appearance of these craggy spikes.

whereas a section through a small crater might resemble the cut-away profile of a breakfast cereal bowl.

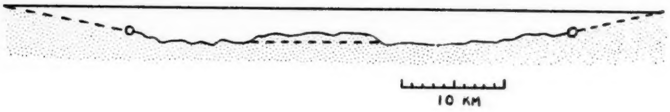
How then has the myth persisted that the moon is a place of grand and rugged scenery? Well, of course, the culprit is the unsoftened light of the sun that strikes the lunar surface at very low angles and which creates conditions something like those made by car headlights glancing along the surface of a road. It is a simple experiment to simulate these conditions, and it is an amusing exercise to try to identify everyday objects—collar studs, match-boxes, and the like—by their shadows cast under these low angles of illumination. Why not try this experiment—you will soon see

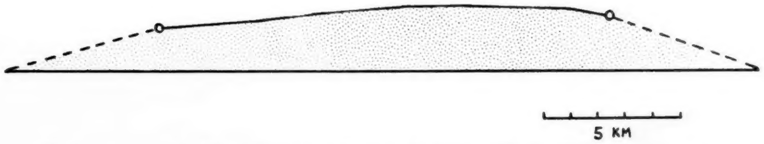
where the idea of the spire-like lunar mountains came from.

But what of the future? We are told that man may be on the moon by 1970; certainly by that time we can expect soft landings of rocket-borne apparatus designed to give information concerning the nature of the lunar surface? We can expect also to hear of other satellites that will go round the moon and will bring back to the vicinity of the earth detailed pictures of the lunar surfaces—detail that is beyond the resolution of our largest telescopes at the present time. As far as the actual shape of the moon is concerned, we are likely to learn more of this from satellite orbits than we are from landings on the lunar surface; the same is true of the earth, and only recently has new knowledge about its shape been acquired from satellites. In this respect we live *too* close to the earth!

There is still much work that we can do from the earth, and daily we hear of new scientific inventions that may be used to probe the secrets of the moon. Little more than a month ago scientists announced that they had perfected an intensely bright source that would be capable of emitting enough light to illuminate the moon from the earth. If this is true, the possibility of mapping the surface of the moon by radar becomes a certainty, for the radio beams of the normal radar installations are too coarse for such work, but light beams are ideal since they will allow us to isolate any desired area on the lunar surface, and, furthermore, we can be certain of receiving echoes or reflections from the actual surface and not from some reflecting layer below the surface of the moon.

The astronomical horizon is bright with promise, and we should consider ourselves fortunate to be living during the most stimulating scientific epoch in the history of the human race. For fifteen hundred years after the birth of Christ the science of astronomy stagnated; it took men like Galileo, Copernicus, Kepler and Newton to revive it. Since then great advances have been made, and, with the latest techniques and the newly forged tools that science has given us, who can tell where our faltering steps will lead us in our search for knowledge. ●





These are scale diagrams, based on a large number of measures and computations carried out by the author, of (above) the crater Aristillus in the Mare Imbrium and (below) the isolated mountain Piton. The dotted lines indicate the probable slopes of unmeasured portions of the formations. North is to the right in both cases. The lower diagram shows what an observer would see of Piton if he were standing a few kilometers to the west of the formation.

LUNAR, SOLAR ECLIPSES IN SEPTEMBER

A total eclipse of the moon and a partial eclipse of the sun will occur during September. Both will be generally visible in North America.

The lunar eclipse will occur on Sept. 5th (Labor Day), the moon entering the umbra of the earth's shadow at 4:36 a.m. (Central Daylight Time). Totality begins at 5:38 a.m. (CDT), and ends at 7:05 a.m. The moon leaves the umbra at 8:07 a.m. (CDT).

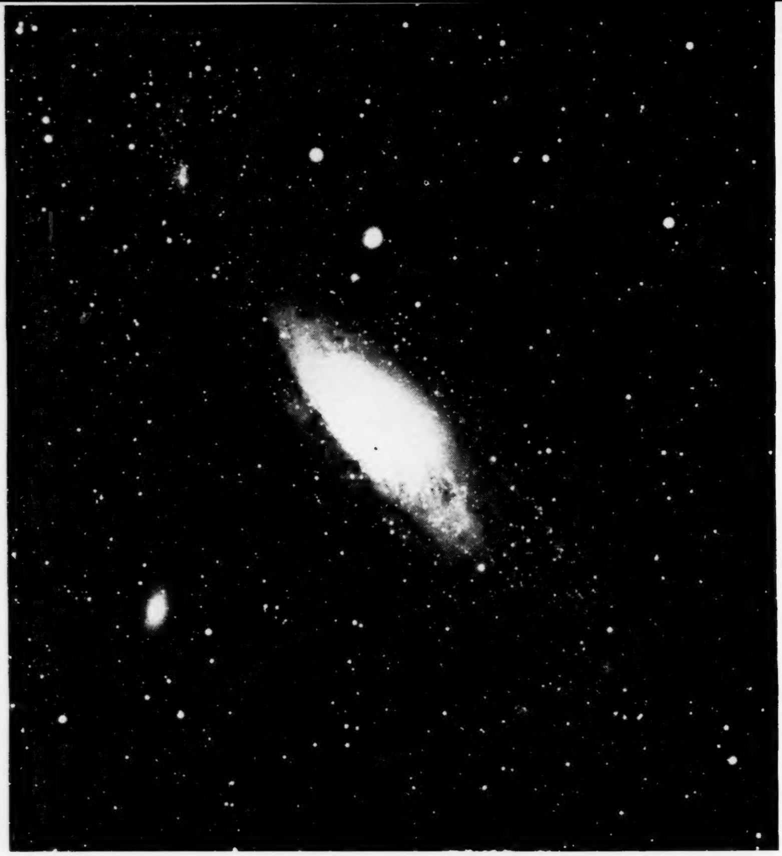
Observers in the eastern part of North America will observe only the umbral or the beginning totality phases of the eclipse, since the moon will be setting before mid-eclipse. Viewers in the Midwest will observe nearly the full totality, and West Coast will enjoy the full run of umbral shadow phenomena.

The full moon will be in Aquarius, and several stars will be occulted during the period between first contact of the umbral shadow and the beginning of totality. Midwestern and Western viewers will see the 6.3 star 78 Aquarii occulted, and western observers will see the reappearance of the star at the moon's western limb during totality. West coast viewers will also have an opportunity to see the reappearance of the 3.8 star Lambda Aquarii just prior to totality. Observers in the Province of Alberta, Canada, will view the emersion during totality, however.

The partial eclipse of the sun occurs on Sept. 20th, totality beginning at 4:09 p.m. (CDT) and ending at 7:50 p.m. (CDT). Most or all of the partial eclipse will be seen in the Midwest and on the West Coast, but the sun will have set before the eclipse begins for viewers on the East Coast. At the height of the eclipse, about 60% of the sun will be obscured by the moon (not by the moon's *shadow*, a gross error occurring in a special-issue astronomy publication magazine now on the newsstands).

WARNING: Even though the eclipse will occur when the sun is near the horizon, do not observe the sun directly, either with the naked eye or with a telescope. Use a dark filter for naked eye viewing, and a solar filter or Herschel wedge prism with a telescope.

On the evening-morning date of Oct. 8th-9th, the 18-day-old moon (four days past full) will occult the 1st-magnitude star Aldebaran (Alpha Tauri) and at least half a dozen of the brighter stars in the Hyades cluster. The occultation of Aldebaran will occur during the early morning hours, and since it is west of the Hyades group, it will be the last star to be covered by the moon. Moonrise occurs at about 8:00 p.m. (local mean time) on the evening of the 8th at 40° N. latitude. Start your viewing after moonrise; stars will disappear behind the bright limb and reappear at the dark limb.



The northern half of Cygnus, with Deneb at top and bar of Northern Cross running diagonally from lower left to upper right. North America nebula is to left of Deneb. From "Atlas of Milky Way," Calvert and Ross.

University of Chicago

THROUGH THE THREE-INCH

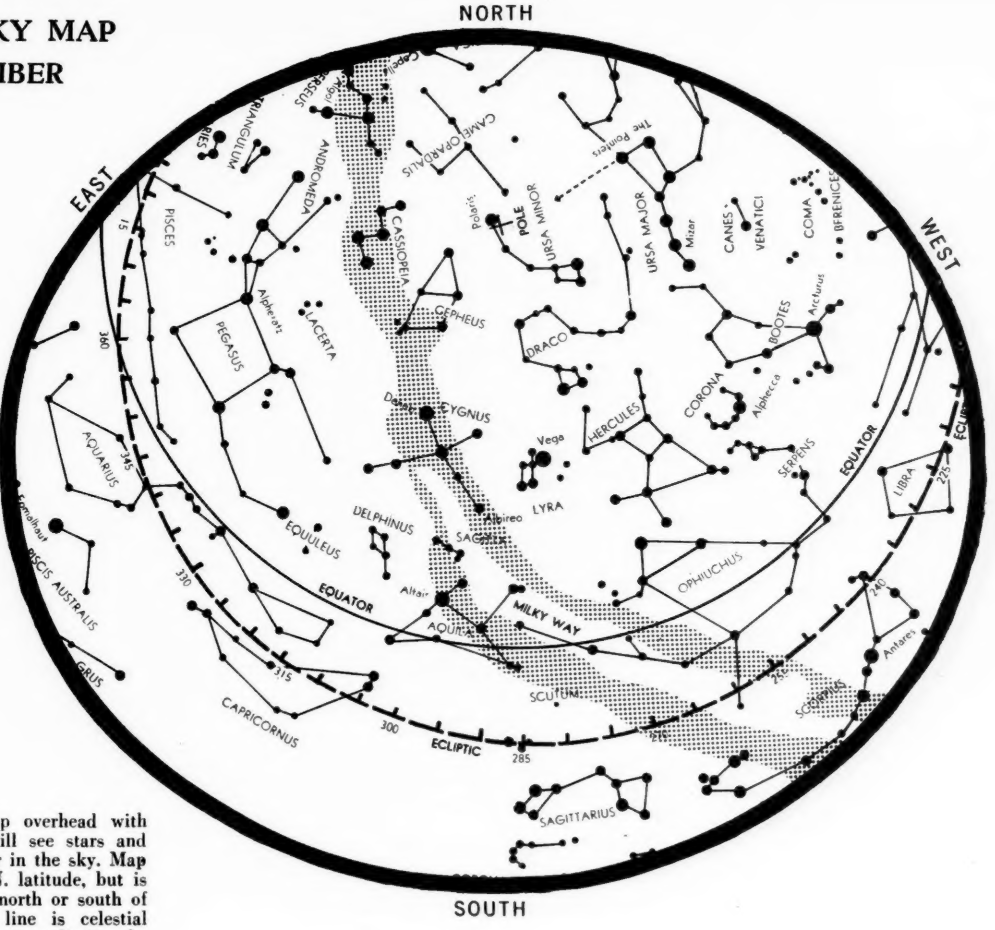
IT IS A HAPPY COINCIDENCE that the cool and invigorating first breaths of autumn also bring with them clear skies, steady seeing and a new array of celestial objects to fill the tube of the small telescope. If this were not enough, the weather also becomes more hospitable as the spirits lift up from the summer doldrums—in fact, it takes a practicing neurotic to find fault with the autumn observing weather. By mid-September the enemy mosquito fleets have nearly lost their control of the air, and we no longer dread the idea of transporting our instruments into the yard only to observe in a bath of perspiration. Our frivolous neighbors, with their klieg-lit badminton courts and smoky, long-enduring barbecues, have turned their orgies indoors, and even the trees begin to bow to the searching eyes of our telescopes and deferentially doff their covering of leaves. Snow, frostbite and icicles are still but a distant memory, and the skies are there above us for the taking.

Even when the smoke of autumn wood and leaf fires settles in layers above us, we soon learn that this is usually an indication of stable conditions in the ocean of air above us. Some of the finest lunar and planetary observing can be done under such conditions, although the glory of the nebula, galaxies and stellar clusters must be reserved for more transparent skies.

We must always remember to differentiate between *transparency* and *seeing*. As we just noticed, steady images are often observed when the skies themselves are quite hazy; conversely, the crackling-crisp skies of mid-winter seldom offer the cold-climate telescopist an opportunity to make the most of his high powers. Star and planet images wave freely as the radiating warmth of the day passes upward from the earth's surface. However, this is not the time for low curses, but for low powers. Enjoy the transparent evenings for what they can afford—excellent wide-field views of the coarse clusters and the rambling galactic nebulae. Then, when the stars are steady and untwinkling and the planets hang before you like sharp etchings, begin your quest for the elusive close double stars and the polar caps of Mars.

But let's not talk about all this—let's do something about it. We will assume that any observer will have procured a good star chart or atlas —such as the Olcott-Mayall *Field Book of the Skies* or, ideally, Norton's *Star Atlas*. Either of these can be found at or ordered through your local bookseller. The two books make a fine combination, and, as with a small 3- or 4-inch telescope, the amateur can live his life with them. The charts in Norton are on a large scale and have the celestial coordinates of right ascension (RA) and declination (Dec), which more or less correspond to terrestrial longitude and latitude. For centuries the ancients described objects as being located "in the great left toe of the Mighty Hunter" and so on, but delightful as this may be in the reading, it can be-

EVENING SKY MAP FOR SEPTEMBER



Face south, hold map overhead with north at top. You will see stars and planets as they appear in the sky. Map is designed for 40° N. latitude, but is practical ten degrees north or south of that latitude. Solid line is celestial equator; dashed line is ecliptic, the apparent path of sun and planets.

8:30 P.M., Sept. 1 (Local Standard Time)

gin to pall when the search is on. At least in these pages, we cannot afford the luxury of such anatomical dead-reckoning, and must resort to the celestial coordinates if we are to tick off the many objects we should like to cover.

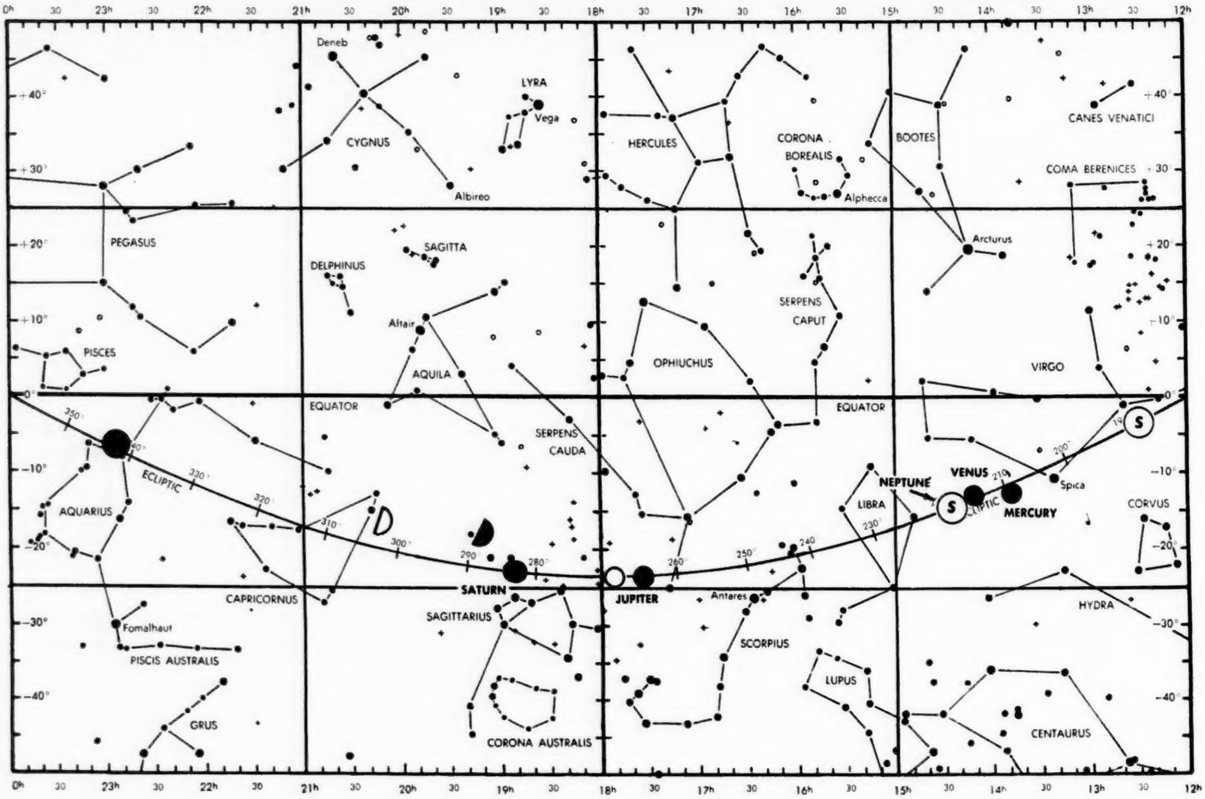
On a mid-September evening, one constellation dominates the zenith as it straddles both the meridian and the seasons. The winged swan Cygnus, already a summertime acquaintance in the later hours, now lies spread out above us as if headed south for the coming winter. Its spread of wings covers a multitude of objects and star-packed Milky Way fields, and they should be explored. Several objects invite special attention, however, and we will mention them here.

At the bottom of the Northern Cross (perhaps more acceptable an identification) lies Albireo the Beautiful. Albireo, or Beta Cygni, is a lovely double star, a contest for no optical system but a bright contrast of blue and gold that demands brief but repeated attention. Magnitudes are 3 and 5—a show object for the neighbors, if they're nice.

But now, another double beckons—this one just at our limit of vision but worth the search, because it was the star that initially shattered our celestial "limit of vision." Forming a perfect parallelogram with Deneb and the central and western stars of the Cross—but there we go; let's call it RA 21h 04m, Dec 38° 28′ N—is the 5th magnitude star 61 Cygni. This number was assigned to it by the first resident of the Greenwich Observatory, Astronomer Royal Flamsteed, who catalogued many of the fainter stars, but it didn't become significant until years later when it fell under the scrutiny of the German mathematician-astronomer Bessel.

The star 61 Cygni quickly resolves into a wide double, its components separated by nearly 30″ of arc and easy in low powers. The two stars, magnitudes 5.5 and 6.5, revolve about a common center of gravity in a period of about 700 years. However, as it is with many objects we see in our telescopes, we must see with our minds as well as our eyes. When Bessel finally pointed his special tele-

(Continued on page 14)



EQUATORIAL SKY MAP

The charts on these pages show the star field from the equator to 50° south and 50° north. Right ascension is measured from west to east in hours; each notch at the top and bottom of the charts represents 10m of right ascension. Declination is measured to the north and south of the equator in degrees plus or minus; each notch at the right and left of the chart represents 5° of declination. Longitude along ecliptic is measured in 10° segments.

SEPTEMBER AND OCTOBER AMONG THE PLANETS

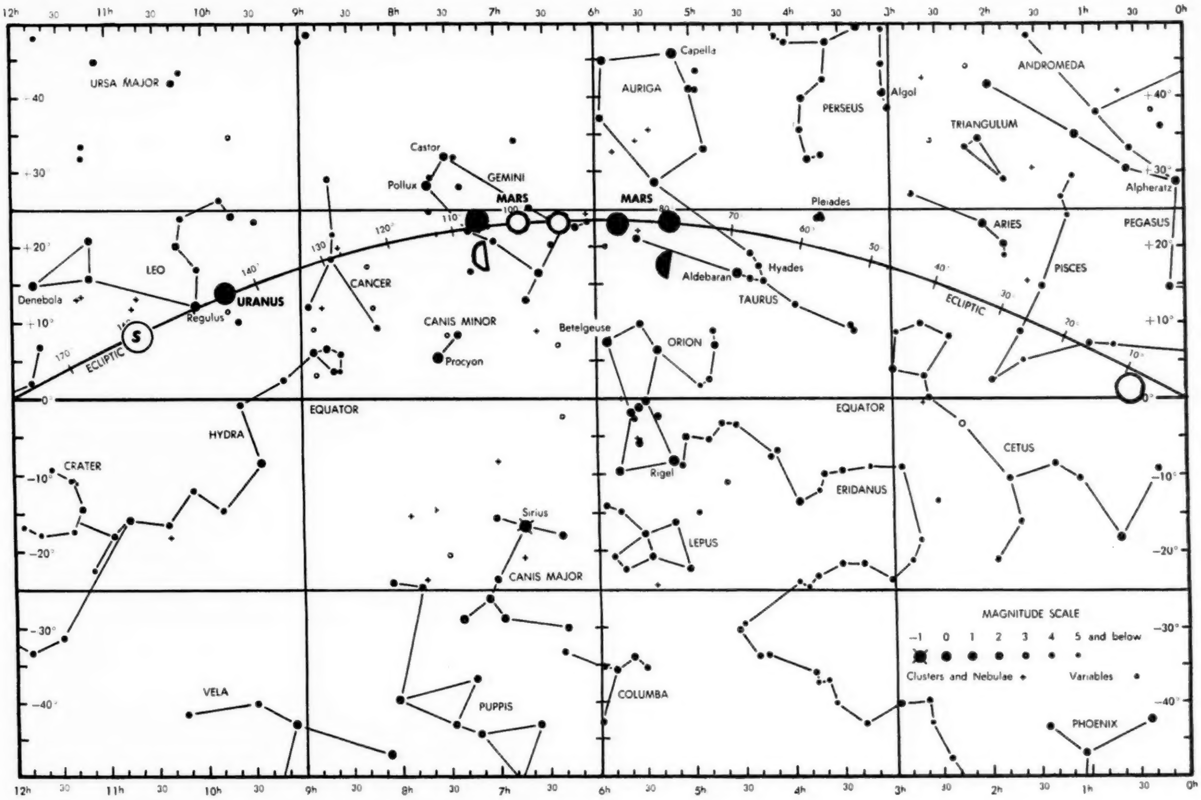
SUN: On Sept. 1st the sun is in Leo at RA 10h 41m, Dec 8° 22′ N; by Sept. 30th it is in Virgo at 12h 25m, 2° 43′ S. On Sept. 22nd at 8:00 p.m. EST the sun moves southward across the celestial equator, marking the autumnal equinox. As the term "equinox" implies (equi: equal; nox: night), day and night are theoretically equal in length at this time; this also holds true for the vernal equinox, which occurs around the 21st of March.

At these two equinoctial points, where the sun's path (ecliptic) crosses the sky equator, we find that the sun rises directly east of us and sets directly west of us—the only times during the year when this is true. Also, observers on the earth's equator would see the sun directly overhead at apparent solar noon. If you were in Quito, Ecuador, and drove a pole perpendicularly into the ground at noontime, it would cast no visible shadow. However, owing to the fact that the sun is almost always a bit "fast" or "slow" in hitting the meridian point at civil noon (clock-time) corrections must be made. Actually, on Sept. 22nd the sun would be running about seven minutes "fast," and you would have to observe your perpendicular pole at about 11:53 a.m. Quito time.

On Oct. 1st the sun is in Virgo at 12h 29m, 3° 06′ S; by Oct. 31st it is at the eastern boundary of Virgo, its position being 14h 21m, 14° 02′ S.

MERCURY: On Sept. 1st Mercury has just passed through superior conjunction (the opposite side of the sun from the Earth), and is too close to the sun for observation during the month. Since the antics of both Mercury and Venus must be observed frequently to be appreciated, the SKY MAP will include a small insert chart showing the rapid movements of these planets at 10-day intervals during the two-month periods. On Oct. 15th Mercury is at its greatest eastern elongation from the sun, and may be seen as an evening star low in the southwest. Although it is 25° east of the sun at this time, it is also nearly 20° south of the equator, making it rather low in the sky. Its actual brightness is 0.1, although the little planet will not be seen in a dark sky. It is most favorably observed as an evening star in the spring and as a morning star in the fall.

VENUS: Venus (see special chart) is now coming into prominence in the southwestern sky after sunset. During September and October it will shine at nearly –3.5 in the twilight sky. Look for it after sunset with binoculars,



Charts indicate position of sun for 1st of each month. Mercury and Venus are shown only for middle of two-month period (see special map below for 10-day positions). Mars is plotted for 1st and 15th of each month; Jupiter and outer planets for 15th of each month. Position and phase of moon is also indicated. Positions of moon and planets in September are shown by *black* circles; for October by *outlined* circles.

Chart is a natural projection and contains all stars through fifth magnitude (and some fainter). Bright stars are labeled with their proper names. Clusters and nebulae in Messier's catalogue are included, as are all variable stars with maxima brighter than magnitude 8.0. Circumpolar stars may be located on the evening sky map for the appropriate month.

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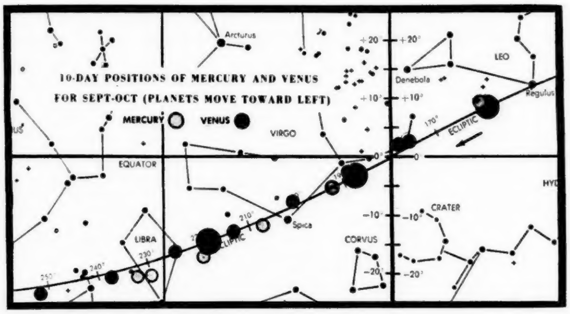
then switch to a small telescope for a better view. Venus is disappointing in a darkened sky because of its extreme brightness.



Mars: Mars begins September in Taurus, between the tips of the Bull's horns, and moves rapidly eastward among the stars until, by the end of October, it lies just west of Delta Geminorum, not far from the discovery position of Pluto just 30 years ago.

On Sept. 1st Mars rises at about 11:00 p.m. (local standard time), shining at 0.6 and showing a disk of nearly 8 seconds of arc (just half the size of Saturn). However, even the small-telescope user can begin to detect a few faint but obvious Martian surface markings during the next two months. At the end of October Mars will be rising in the northeast at about 9:00 p.m. (local standard time). It will then exhibit a disk of more than 11 seconds of arc and will be conspicuous in the lat evening sky at –0.2. Although Mars will be less than two-thirds the diameter it displayed at its close approach in 1956, it will gain observationally over that opposition because of its high altitude. In mid-northern latitudes, Mars will be near the zenith at its culmination point and therefore not subject to many of the blurring atmospheric effects experienced by observers in 1954 and 1956.

Jupiter: Jupiter moves little during these two months, less than 8° to the east from Ophiuchus into Sagittarius. Its equatorial diameter is still impressive—40 seconds of arc in early September to 35 seconds at the end of October. However, in early September it sets before midnight, and by late October it can be glimpsed but brief-

ly in the southwestern sky after sunset. Its magnitude at that time is about –1.6. Tables for the date, time and position of its satellites and their phenomena may be found on page 13.

SATURN: East of Jupiter in Sagittarius, Saturn resumes eastward motion through the Milky Way on Sept 15th. Although Saturn's apparent size diminishes from nearly 18 seconds of arc to 16 seconds during these two months, its unique ring system is more than double that of the ball itself and continues to afford interesting views. It may be of interest to note that Saturn's rings are approximately the same angular size as Jupiter's disk at this time, while the actual globe itself at the end of October will exhibit a disk about equal to that of Mars when it reaches opposition in late December. The amateur will spot little or no detail on Saturn, but Mars will furnish views of interest to any observer at the time of opposition.

URANUS: Uranus is still in Leo, rising shortly after midnight but of no special interest.

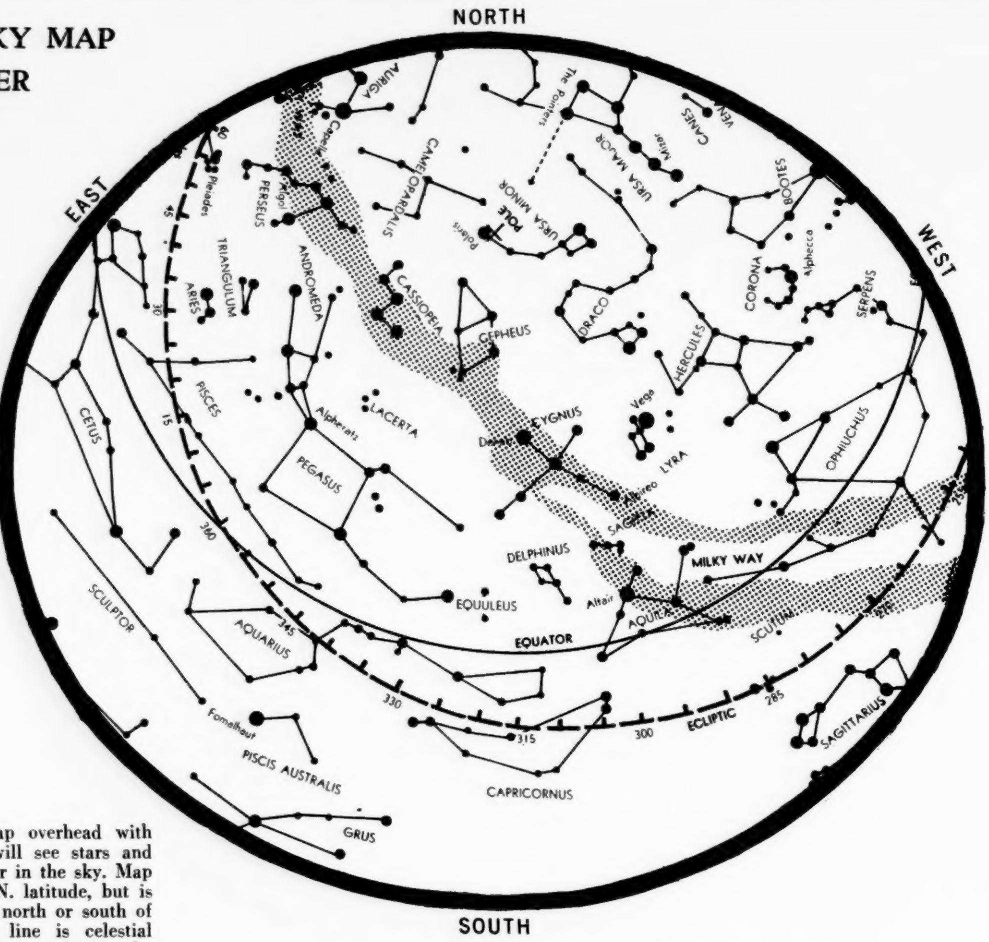
NEPTUNE: Neptune is between Virgo and Libra, rising shortly before sunrise.

BEGINNING AND END OF MORNING TWILIGHT (LOCAL MEAN TIME)

	Beginning				End			
Latitude (N.)	30°	35°	40°	45°	30°	35°	40°	45°
Sept. 1	4:14	4:04	3:51	3:35	**7:45**	**7:55**	**8:07**	**8:22**
6	4:17	4:08	3:57	3:43	**7:38**	**7:47**	**7:58**	**8:11**
11	4:21	4:13	4:03	3:50	**7:31**	**7:39**	**7:48**	**8:00**
16	4:24	4:18	4:09	3:58	**7:24**	**7:31**	**7:39**	**7:49**
21	4:27	4:21	4:14	4:05	**7:18**	**7:23**	**7:30**	**7:39**
26	4:30	4:26	4:20	4:13	**7:12**	**7:15**	**7:21**	**7:28**
Oct. 1	4:34	4:30	4:25	4:19	**7:05**	**7:08**	**7:12**	**7:19**
6	4:37	4:34	4:30	4:26	**6:59**	**7:01**	**7:04**	**7:08**
11	4:40	4:38	4:35	4:32	**6:53**	**6:54**	**6:57**	**6:59**
16	4:42	4:42	4:40	4:38	**6:48**	**6:48**	**4:49**	**4:52**
21	4:45	4:46	4:46	4:44	**6:43**	**6:42**	**6:42**	**6:43**
26	4:49	4:49	4:50	4:51	**6:43**	**6:42**	**6:42**	**6:43**
31	4:51	4:54	4:56	4:57	**6:35**	**6:33**	**6:31**	**6:29**

These twilight tables are designed to guide the observer in planning his observing schedules. Two corrections must be made if accuracy is desired: Observer's latitude must be interpolated if it is between latitudes used in the table; and local mean time of tables must be converted to standard time of observer's zone. **Add** 4 minutes for each degree **west** of nearest standard time meridian; **subtract** 4 minutes if **east** of meridian. (To convert daylight saving time, add 1 hour.) Light type—a.m. **Bold type**—p.m.

EVENING SKY MAP FOR OCTOBER



Face south, hold map overhead with north at top. You will see stars and planets as they appear in the sky. Map is designed for 40° N. latitude, but is practical ten degrees north or south of that latitude. Solid line is celestial equator; dashed line is ecliptic, the apparent path of sun and planets.

8:30 P.M., Oct. 1 (Local Standard Time)

SKY WATCHER'S D

SEPTEMBER

Date	Hour (EST)	Event
1	03	Saturn 4° S. o
	15	Asteroid Pallas
2	16	Moon at perig miles)
5	06	Full moon (l see p. 7
11	20	Aldebaran 0°
12	17	Last quarter
13	05	Mars 5° N. o
14	13	Moon at apo miles)
15	15	Saturn stati
18	02	Uranus 3° N
20	07	Venus 3° N
	18	New moon eclipse; se
22	01	Mercury 3
	17	Venus 3°
	20	Autumnal
23	16	Neptune 3°
26	11	Mercury 1°
27	05	Jupiter 5° S.
	20	First quarter
28	09	Saturn 4° S. o
29	17	Moon at perigee (229, miles)

OCTOBER

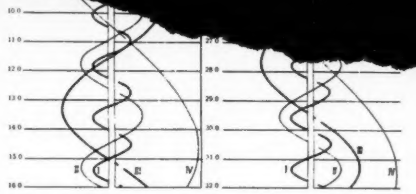
Date	Hour (EST)	Event
3	22	Venus 2° S. of Neptune
4	17	Full moon
8	01	Asteroid Ceres stationary
	17	Mercury 4°.3 S. of Neptune
9	04	Aldebaran 0°.3 S. of moon
11	17	Mars 5° N. of moon
12	08	Moon at apogee (251,200 miles)
12	12	Last quarter moon
15	13	Uranus 3° N. of moon
	17	Mercury greatest elongation E. (25°)
20		Orionid meteor shower
	07	New moon
21	23	Mercury 8° S. of moon
22	16	Venus 6° S. of moon
24	15	Moon at perigee (229,000 miles)
	17	Jupiter 5° S. of moon
25	16	Saturn 4° S. of moon
27	03	First quarter moon
	14	Mercury stationary in orbit
28	15	Venus 3° N. of Antares

(Times are for EST, 24-hour clock. For areas on daylight saving time, add one hour, then convert to standard time of your zone: CST, MST, PST, etc.)

13	19:08		
14	19:25		
	19:55	I	
21	19:36	I	
24	19:02	II	
26	19:05	II	ER

(Times EST) E—eclipse (satellite passes into shadow of planet); O—occultation (satellite passes behind planet); T—transit (satellite or satellite shadow passes across disk of planet); S—shadow (shadow of satellite cast on disk by sun); D—disappearance; R—reappearance; I—ingress (entrance upon disk); e—egress (exit from disk). Satellite designations: I—Io; II—Europa; III—Ganymede; IV—Callisto.

(Data adapted from 1960 American Ephemeris and Nautical Almanac.)



EXPLANATION OF SATELLITE DIAGRAM

Effective with the unification of the British and American Nautical Almanacs this year, the configurations of Jupiter's bright satellites are now presented in a new and more useful type of diagram.

The central vertical band in the diagram represents the equatorial diameter of the disk of Jupiter. The relative positions of the satellites at any time with respect to the disk of Jupiter are given by the curves. In cases where a satellite is immersed in the shadow of Jupiter or occulted by its disk, the curve is interrupted.

The horizontal lines show the positions of the satellites at Oh Universal Time (Greenwich Mean Time) for each day of the month. For example, the horizontal line for the 15th of this month would show the positions of the satellites at 7:00 p.m. on the 14th of the month for an observer in the Eastern time zone.

(Diagrams taken from 1960 *American Ephemeris and Nautical Almanac.)*

at Andromeda galaxy, 33, rides high above on nights. This striking ph was made by Alan of Los Angeles, using Fecker triplet lens. is bright in a small

the
showed a
proper motion—an apparent yearly movement at right angles to our view of some 5″ of arc per year; a considerable one. The odds were, therefore, that it was close to us. Likewise, because of the wide separation of its two components, Bessel reasoned again it would be close. So, just as we might hold our finger in front of our face and blink one eye, then the other, and watch our finger "jump" back and forth against the background in the room, so did Bessel make a series of observations at different times of the year that showed 61 Cygni being slightly displaced against the "fixed" background of the fainter, more distant stars. Soon, in 1838, Bessel was able to announce that 61 Cygni was 11 lights years from the earth, and astronomy had a new yardstick.

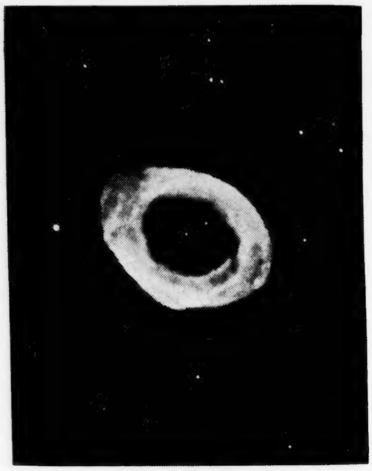
Northwest of Deneb near the star

ed in

toward Albireo, then west a bit. We will cheat for a moment and trespass upon the nearby asterism of Vulpecula for a round with the Dumbbell nebula. Actually, this nebula is most easily found by moving about 3° north of Gamma Sagittae, the point of the little arrow that is so well seen when it is noticed. The coordinates of the nebula (M27) are RA 19h 57m, Dec 22° 35′ N. Actually, it is a planetary nebula, two sides of which are rather tenuous. Therefore we do not see it as a fully rounded envelope of expanding gas as in the case of other planetaries (so named for their superficial resemblance to planet disks). Its shape is very much like a dumbbell in small instrument, although in long-exposure photos it loses its distinctive shape.

Already prominent and readily available to the east is Cygnus' nearby companion, Lyra, full of pleasures. Vega, of course, is the celestial landmark of the skies at this time, and just northwest 2° is the "double-

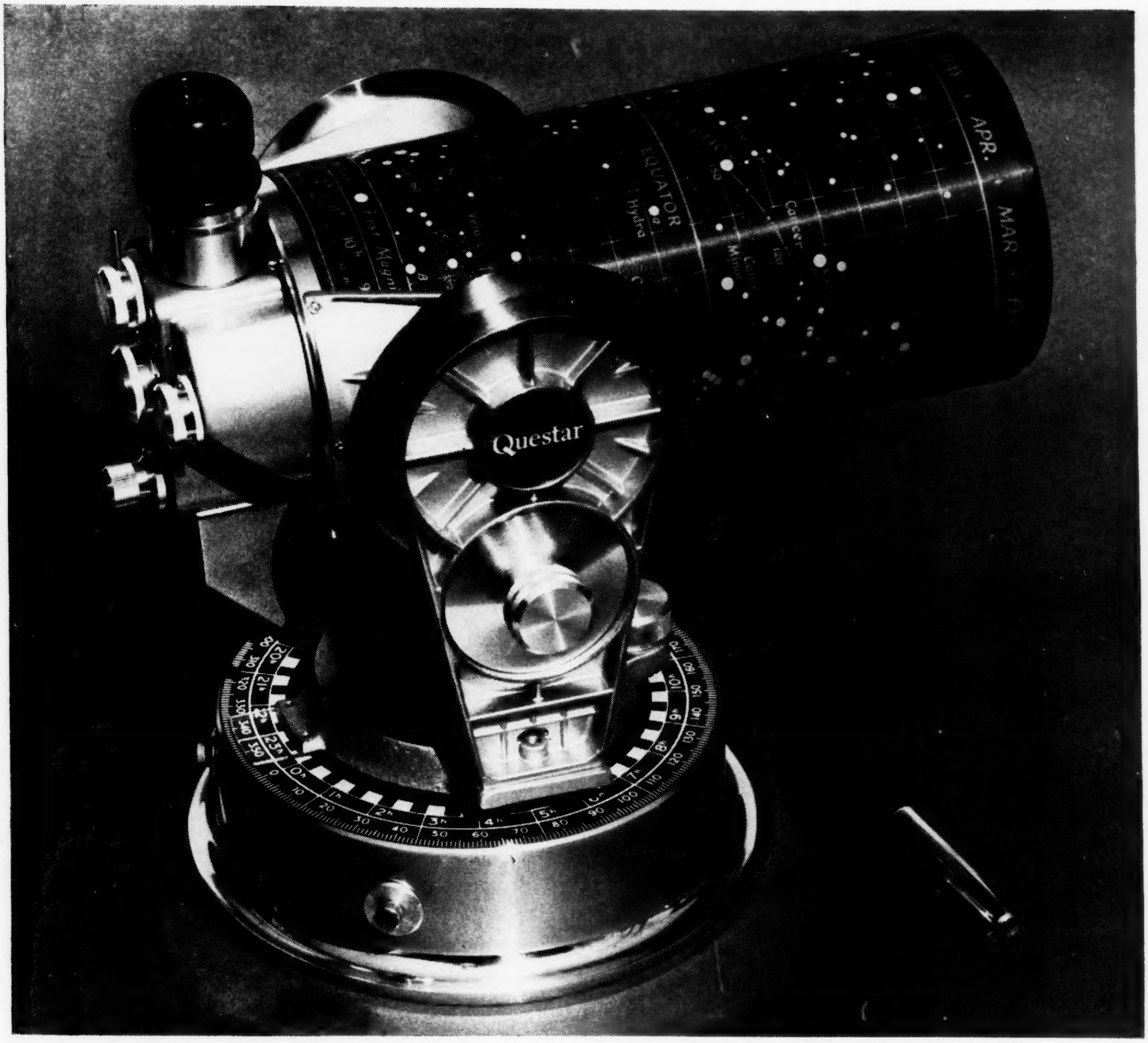
Lyrae. The "first" and Epsilon² as the designated, is obglass, finder or to a n, by using fairly 3-inch can readily se two stars into a bles. The two pri- 3.5′ of arc apart, panions offer more separations of 2″ ght for a small inssible. You won't to locate Epsilon a small equilateral ga and Zeta Lyrae, forms the northern- of the Lyre's prominent parallelogram.



Ring Nebula in Lyra (M57).
Mt. Wilson-Palomar

From Epsilon Cygni there is but one direction to go—south to the Ring nebula. It is positioned nearly centrally on a line between Beta and Gamma Cygni, slightly nearer Beta. (RA 18h 52m, Dec 32° 58′ N.) Numbered 57 in Messier's catalogue, the Ring nebula is a bright planetary.

(Continued on page 20)



LAY THAT BURDEN DOWN

When you finally get tired of lifting and carrying your telescope in and out of doors, tired of setting it up and taking it down in chilly darkness—

When you've had enough of heavy loads, of quivering tubes and images, enough of drives that falter and slow motions that fall short—

When you finally realize that it has become too much trouble to use your telescope any more because it only gives you an aching back and a pain in the neck—when you've had your fill of the contraption—*send for the Questar booklet!*

The Questar booklet will tell you how to lay your burden down. No more lifting, no more toting, no more setting up of heavy, clumsy parts. Questar weighs but 7 pounds, and is always assembled, always ready to use.

It will tell you about how Questar stands alone, the only thing of its kind, with the latest discovery in optics, the mixed lens-mirror system of the new catadioptric optics. How Questar's folded focal length keeps it fabulously short, how so short a telescope can be as stiff and rigid as a great observatory instrument. It will tell you how Questar's images are as rock steady as a microscope, how its controls are ready to your fingertips, and how its 360° continuous slow motions have a buttery smoothness with absolutely no backlash at all. It will tell you of finer performance than was ever dreamed of from only 89 mm. of aperture, and prove that point by the amazing resolution of the photographs it takes.

But hold on—let the booklet tell you this—let us use this space to tell you other things.

Let us speak, for instance, of investment value. Questar costs no more than ordinary 'scopes would if they were so well mounted as to be equally solid and vibration free. But let's face it—Questar optics cost more by the extra hours of human labor required to make, for example, mirrors that must be 16 times more accurate of figure than the ordinary kind. Questar's mounting, too, has over 235 separate parts, each one of the best procurable alloys down to the last tiny screw.

So let us tell you what we have found out—that Questars are so greatly in demand that the few which reach the second-hand market depreciate an average of less than 7% per year! Imagine this—Questars over three years old bring 80% of their purchase price! We know of nothing manufactured with such amazingly high value at resale.

Remember then, that if you too become a Questar owner, you will be making the most conservative investment possible. We firmly believe that it will cost you less per year to enjoy a Questar.

Questar, as illustrated, still costs only $995 postpaid, in hand-made, velvet-lined English leather case. Terms are available. May we send you the booklet?

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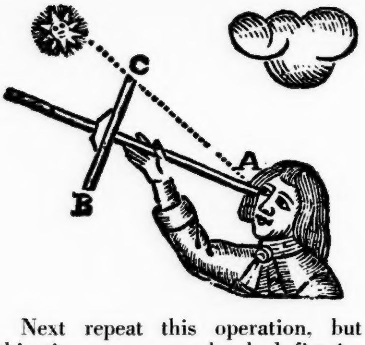
BOX 40 · NEW HOPE · PENNSYLVANIA

LET'S LEARN ASTRONOMY



YARDSTICKS IN THE SKY

Mr. Burkham, a science instructor at the John Burroughs School in St. Louis, found his long interest in astronomy further spiced by a tour of duty as an aerial navigator during World War II. His special interest lies in the area of graphical and mathematical calculations which explain the basic movements and relationships of celestial bodies—and in the application of these by the student or beginner of any age. He has been a contributor to the St. Louis POST-DISPATCH *on astronomical subjects and, prior to his war-time tour as a navigator, was an instructor at the St. Louis Country Day School. His contributions will be a regular feature of the* SKY MAP.

After identifying some of the constellations such as the Big Dipper, Little Dipper and Orion, and spotting the planets, the observer is usually curious to discover quantitative measurements he can make without elaborate equipment. Many reports in the daily newspapers quote casual observers as saying a fireball appeared so many miles above the earth, travelling so many miles per hour; similarly with meteors and man-made satellites. You may have wondered—how did these people estimate these distances? Is it possible for you to measure the distance to the sun and other visible members of the solar system such as the moon and nearer planets? These questions I hope you will be able to answer when you have finished reading this article.

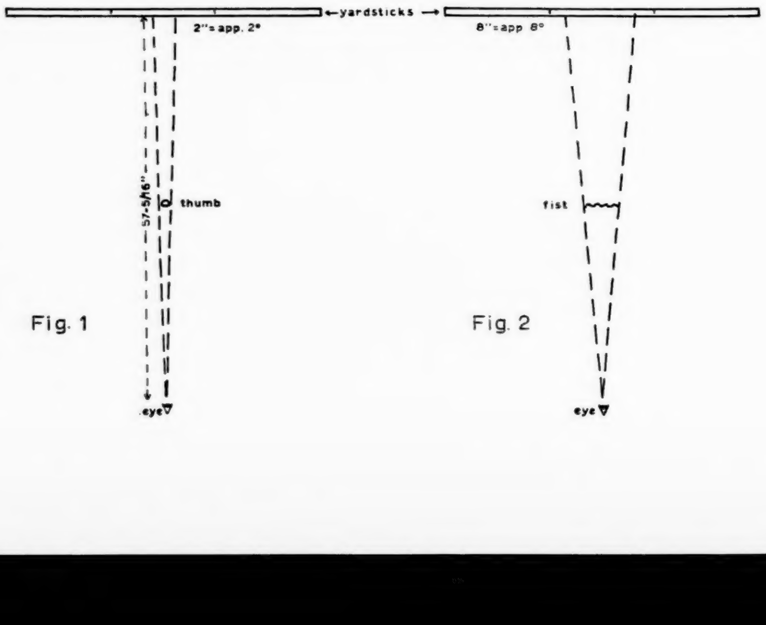
One of the important units used in the science of astronomy is that of angular measurement. The basic unit of angular measure is, of course, the degree — defined as 1/360th of a circle. This unit probably was originated in about 2,000 B.C. by the Babylonians, who divided the year into 360 days, and thus found this to be a convenient measure. The degree is further divided into 60 minutes of arc (always spoken of as "minutes of arc" to prevent confusion with "minutes of time"); and each minute of arc is further divided into 60 seconds of arc (similarly spoken of as "seconds of arc").

In using the degree, your first problem is to determine just how big a degree is and how it is measured in the sky at night. It so happens that if your eye is exactly 57¼ inches from a yardstick (marked in inches) perpendicular to your line of sight, each inch on the yardstick covers, or subtends, an angle of 1° at your eye (Fig. 1). Set up the equipment as shown. Then extend your arm and, with your thumb at right angles to your arm, determine the number of inches on the ruler which are covered by your thumb. It will cover approximately 2 inches, and therefore will subtend an angle of approximately 2°. Try this several times and average your results so that you get an accurate measurement of your thumb with ¼°.

Next repeat this operation, but this time use your clenched fist instead of your thumb (Fig. 2). Sight over your knuckles and you will find they subtend an angle of approximately 7° to 9°. Make several determinations of this, average the results and enter your average in the table.

Now for the last angular measurement—with your arm extended, spread your fingers and read the inches (degrees) from the tip of your thumb to the tip of your little finger. This will approximate 20 degrees. Average the result of several determinations and enter this average in the table.

If a large group of people is making these angular measurements simultaneously, it is more convenient to use the foot (instead of the inch) as the unit of measurement. In the past I have used an 8-foot vertical rod marked off in feet. The students making the measurements stand on the arc of a circle which has been scribed on the ground with a radius of 57′ 4″. In this case, of course, each *foot* on the vertical stick subtends an angle of 1° when the eye is 57′ 4″ distant. For the measurement of the angle subtended by the extended fingers, the students must move up



to a circle of 14′ 4″ radius (57′ 4″ ÷ 4). At this distance each foot on the vertical rod subtends an angle of 4° at the eye.

Many years ago this rough method of angular measurement was pointed out to me while steaming along the coast of Norway by an instructor in marine navigation at the University of Oslo, Norway. Time after time, he was able to measure by this method the elevation of the sun and stars above the horizon within 1° (checked later with a sextant). With a little practice you can do as well.

Now you can use your newly acquired skill to determine the angular diameter of the moon. First, estimate if you can cover the moon with your thumb when your arm is extended. Then, by actual trial, you will find your thumb more than covers it. The moon's angular diameter will vary from approximately 29.4 to 33.4 minutes (′) of arc, which approximates ½°. Later you will see how this looks in a scale drawing.

To continue with our angular measurements, locate Polaris (the North Star) and measure its angle above the northern horizon. To find your *true* horizon, place a glass of water at eye level on a post, table, automobile or other support (illuminate the water level with a weak flashlight or one covered with red paper to reduce the intensity of its light). Position yourself so that the glass of water is directly in line with your eye and Polaris, and then measure the angle from the water level up to the star (Fig. 3). Make several trials and then average them. Estimate the fractional portions of your thumb, fist, or hand.

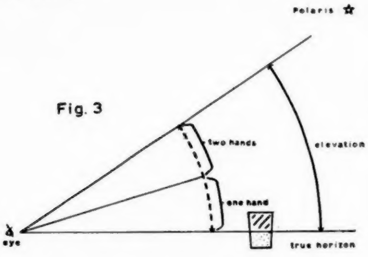
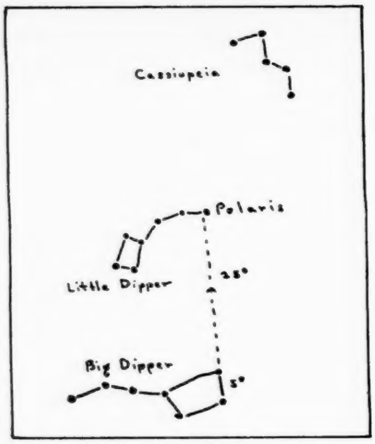


Fig. 3

You will find that this angle (known as the elevation) for Polaris is equal to your latitude (within 1°). The declination (angular distance from the celestial equator) of Polaris is approximately 89° north, and therefore it makes a circle around the north celestial pole with a radius of one degree. If Polaris were exactly at the north celestial pole, where the declination is 90°, the angle of elevation of Polaris would always correspond exactly to the latitude of the place of observation. Since the true declination of Polaris is 89° (not 90°), the angle of elevation will vary as much as 1° below to 1° above the true latitude.

As you travel between latitudes you will notice the change in this angle. As you move *northward* the umbrella of the heavens appears to tip *southward*, and Polaris rises higher in the



sky. Likewise, a traveler journeying *southward* sees Polaris dip lower to the *north*.

A "Do-It-Yourself" Sky Map

To practice your skill at measuring angles with your thumb, fist, and extended fingers, try drawing a map of the northern sky. Put in the horizon, Polaris, the stars of the Big Dipper, and the stars of Cassiopeia. If this is done with a group, compare your drawing with others in your group. In making this drawing, place Polaris in the center of your paper ($8\frac{1}{2}'' \times 11''$). By using a scale of 1/10 in. = 1°, these constellations and the horizon will all fall on the paper as long as the latitude of your location is between the equator and 47° north (Fig. 4).

Measurements of the Moon

You have seen above that the moon subtends an angle of less than your thumb. In fact, the angle is approximately ½°, so it is only about ¼ as wide as your thumb. To visualize this small angle a scale drawing is helpful. On a sheet of plain paper, using a protractor, draw an angle of ½ a degree. You will find this quite difficult even with a hard pencil and a sharp point. Fortunately, there is an easier way. From mathematical tables it can be determined that, in a right triangle, where the small angle is 1°, the long side of the triangle is 57.3 times the length of the short side (0.01745 = tan 1°, 57.3 = cotangent 1°). This angle is readily drawn on your paper by drawing a line 57.3 mm (millimeters) long and a line at right angles to it 1 mm long (Fig. 5a). Complete the triangle and now you have constructed an accurate angle of 1°. In order to draw your angle of ½°, it will immediately occur to you merely to halve the short side of the triangle above. While this is theoretically possible, your scale drawings are most accurate when they are as large as possible and still fit on the paper. If you multiply the above triangle by four, the length of the long side will be 229.2 millimeters long and the short side will then be 4 mm long. It is now evident that the small angle of the triangle is still 1°, so to make the required angle of ½°, merely divide the short side of the triangle by 2 and connect this to the apex (Fig. 5b). You now have quite an accurate scale drawing of the moon as seen from the earth.

Now, it may occur to you that, if you knew the diameter of the moon, the solution of a simple proportion would give you the distance to the moon. (The diameter of the moon is 2,160 statute miles). Knowing this, you can set up the following simple proportion:

$$\frac{\text{short side in mm}}{\text{long side in mm}} = \frac{\text{dia. of moon in miles}}{\text{dist. of moon in miles}}$$

$$\frac{2}{229.2} = \frac{2160}{\text{distance}}$$

$$\text{distance} = \frac{2160 \times 229.2}{2}$$

$$\text{distance to moon} = \text{about } 247{,}000 \text{ miles}$$

From this simple proportion it can be seen that a formula may be derived to solve any distance problem for celestial bodies when the diameter of the body and the angle subtended by the body are both known.

If the angle is given in degrees, as in the previous moon example, the formula takes the form:

(1)

$$\frac{\text{dist. to body in miles}}{\text{diam. of body in miles}} = \frac{57.3}{\text{degrees of arc}}$$

(Note: 57.3 is the cotangent of 1°)

Repeating the problem for the moon:

$$\frac{\text{dist. to moon in miles}}{2160 \text{ miles}} = \frac{57.3}{0.5 \text{ degrees}}$$

$$\text{distance} = \frac{2160 \times 57.3}{0.5}$$

$$\text{distance to moon} = \text{about } 247{,}000 \text{ miles}$$

When the angle subtended by the body is given in *minutes* of arc, not in *degrees* of arc, the formula becomes:

(2)

$$\frac{\text{dist. to body in miles}}{\text{diam. of body in miles}} = \frac{3438}{\text{minutes of arc}}$$

(Note: 3438 is the cotangent of 1′)

Repeating the problem of the moon using *minutes* of arc (30′ = ½°):

$$\frac{\text{dist. to moon in miles}}{2160 \text{ miles}} = \frac{3438}{30' \text{ of arc}}$$

$$\text{distance} = \frac{2160 \times 3438}{30}$$

$$\text{distance to the moon} = 247.000 \text{ miles.}$$

Actually, the moon does not always subtend the same angle, as its distance from us varies due to the eccentricity of its orbit. In the months of September and October, 1960, the actual angles (in minutes of arc) subtended by the moon at 5-day periods are given in the following table:

Date	(September) diam.	Moon's distance
1	32.8′	
5	32.4′	
10	30.4′	
15	29.6′	
20	30.6′	
25	32.0′	
30	32.4′	

Date	(October) diam.	Moon's distance
1	32.2′	
5	31.4′	
10	29.8′	
15	30.0′	
20	31.8′	
25	32.4′	
30	31.6′	

The distances in the above table can be calculated from formula (2) above.

Planet Distances

The angles subtended by the planets, being small, are most conveniently measured in *seconds of arc* (60 seconds of arc = 1′ of arc). The abbreviation for seconds of arc is

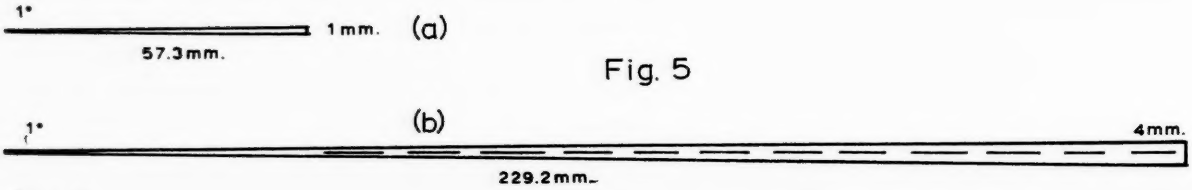


Fig. 5

(″). A further adaptation of formulas (1) and (2) is:

(3)

$$\frac{\text{dist. to body in miles}}{\text{diam. of body in miles}} = \frac{206{,}262}{\text{seconds of arc}}$$

(Note: 206,262 is the cotangent of 1″ of arc)

The angles subtended by the naked-eye planets and their diameters in miles are given in the following table:

Body	Diameter in miles	Angular diameter Oct. 1, 1960
Mercury	3,100	5″
Venus	7,500	12″
Mars	4,150	9″
Jupiter	87,000	35″
Saturn	71,500	15″

Example: Find the distance to Mars when it subtends an angle of 7″. Use formula (3) which is designed for angles measured in seconds of arc.

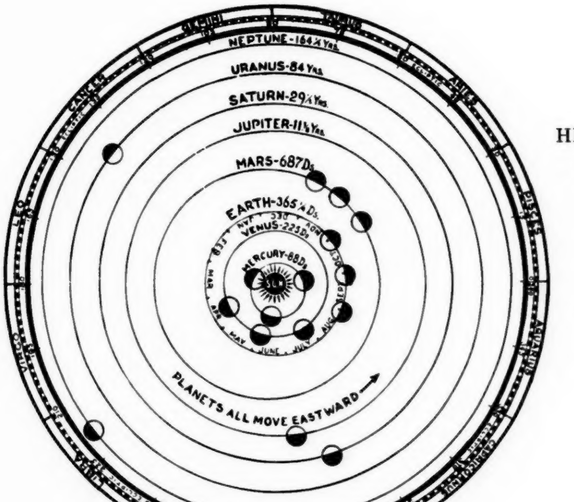
$$\frac{\text{dist. to Mars in miles}}{\text{diam. of 4150 miles}} = \frac{206.262}{7''}$$

$$\text{distance} = \frac{4150 \times 206.262}{7}$$

$$\text{distance to Mars} = 122{,}280{,}000 \text{ miles}$$

Referring now to the questions which were suggested in the first paragraph of this article, you can easily understand that, to measure the distance to any object in the sky, it is first necessary to know its size in linear dimensions (feet, miles, etc.). The only measurement you can make with your eye is that of the angle subtended by the object. This, by itself, is not enough information to determine the object's distance. A fly at 100 feet might appear the same size (subtend the same angle) as an unidentifiable object in the sky 1,000 miles away, yet without knowing their respective sizes it is impossible to determine their respective distance.

Similarly, speeds of objects in the sky cannot be measured with the eye except as angular units per unit of time, such as 2° of arc per second. You cannot assess the speed of the object without knowing its size in linear units, its diameter in angular units at the beginning and end of the timing period, or its radial velocity plus its actual size in linear units. From this you can appreciate that you cannot possibly tell the linear speed of an object observed casually in the heavens. Be skeptical of newspaper articles which tell the distance and speed of unidentified celestial or atmospheric objects. ●



HELIOCENTRIC POSITIONS of the PLANETS for SEPTEMBER and OCTOBER 1960

This chart shows the solar system as it would appear if viewed from a point directly above the sun (in relation to the plane of the ecliptic). Heliocentric positions of the planets are measured in degrees of longitude, eastward from the First Point of Aries. Owing to space limitations, the orbits of outer planets are not to scale. Positions at beginning, middle and end of two-month period are shown for Mercury, Venus, Earth and Mars—mean position during period is shown for each of the outer planets.

METEOR FRAGMENTS

IT WOULD almost seem that the August Perseid shower produces a run on Nature's "meteor bank," for September brings but one meteor shower, the Epsilon Perseids. This shower, according to Norton's Atlas, extends from the 7th to the 15th, but the rates will almost certainly be quite low.

October brings one major shower, the Orionids. According to Dr. P. M. Millman, the maximum will occur during the sunrise hours on Thursday, Oct. 20th. It spreads over about eight days, with a maximum of about 25 per hour (for all meteors). New moon also occurs Oct. 20th, so observations can be made at any time of night that the radiant is above the horizon. The area from which the shower appears to radiate is at RA 6h 20m and Dec 15° N., which is about 9° northeast of Betelgeuse, the great red giant in Orion. The radiant rises at about 9 p.m. in mid-northern latitudes and culminates (highest due south) at about 4 a.m. (local standard times). The history of the shower shows that it has never been recorded in great numbers, but varies from year to year—from about 6 to about 18 Orionids per hour.

A few interesting side-lights—excepting the Leonids, the Orionids have the highest orbital velocity of any shower meteors, namely 41.2 miles per second, which makes them tend to appear quite swift and leave trains or streaks in their wakes. According to Fletcher Watson's book, *Between the Planets*, only one Orionid spectrogram has ever been obtained. This photographic spectrum indicated that the meteor was very much like the Perseids, since strong lines of calcium, magnesium and silicon were found.

It was once believed that Halley's Comet produced both the Eta Aquarids and the Orionids. However, according to A. C. B. Lovell (*Meteor Astronomy*), it is now not at all sure that there is any connection between the Orionids and Halley's Comet.

Observers are urged to count the Orionids by the hour. It is suggested that interested observers consult the July-August issue (p. 13) of THE MONTHLY EVENING SKY MAP for the detailed observing procedure.

ADMONISHMENT: make and report only *individual* counts for *one hour or more.* It is fine to observe with a group, but the totals must *not* be merged, as group totals are unusable for scientific study. Observations should be sent to this magazine, whenceforth they will be forwarded to the appropriate American Meteor Society regional director.

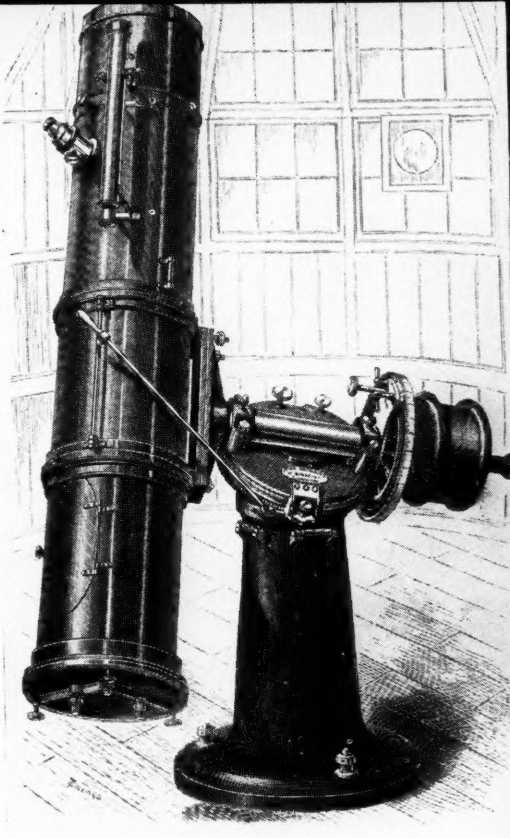
Edwin E. Friton
Regional Director
American Meteor Society

(Continued from page 14)

What we see is an expanding and spherical envelope of gas resulting from the explosion of a star many eons ago. However, the central part of the sphere—from our point of view here on earth—is too thin to be visible in a small instrument. Instead, we see only the outer portion of the gaseous sphere, still lighted from within by a faint 14th-magnitude star. Thus, we get the impression of viewing a distant celestial smoke-ring. M57 bears magnification well, and a 3- or 4-inch instrument at 100x should easily show the "hole" against a dark sky. The nebula will appear to be about twice the current size of Jupiter.

YOUR TELESCOPE AND MINE

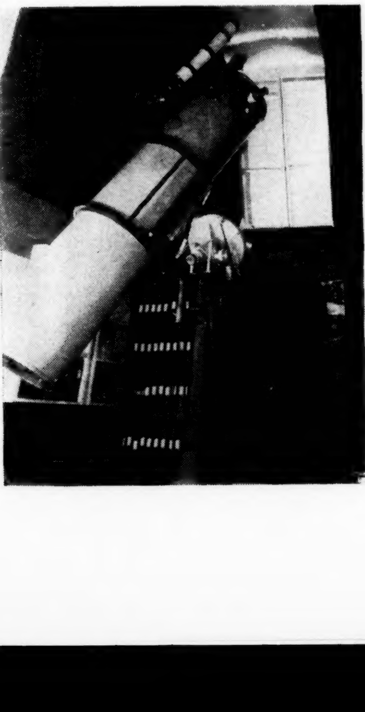
THOMAS R. CAVE, JR.



An equatorially mounted With-Browning reflector. Mirror-maker With was first to put the silver-on-glass reflector in hands of the English amateur. From wooduct in Chamber's Astronomy, Vol. 2.

ALTHOUGH THE TELESCOPE is 350 years old this year, the modern amateur's reflecting telescope is only one hundred years old. The process of silvering a glass mirror was not discovered until 1856, when Liebig in Prussia and Foucault in France independently developed this chemical process. While endeavoring to find a scientific method of testing and figuring parabolic telescope mirrors of glass, Foucault developed the now famous knife-edge test, made at the radius of curvature of a mirror. While Foucault did manufacture several silvered glass mirrors for the University of Paris and other French universities, he never built mirrors or telescopes for amateur observers.

The first reflecting telescopes having mirrors of silvered glass were made in England in 1859 by George With. With was the headmaster of a fashionable school for young ladies at Hereford, but devoted his leisure time to experiments in chemistry and physics. Learning of a successful method of depositing silver chemically on glass, he rapidly developed his own silvering method. In the early 1850's With had tried his hand at polishing and figuring speculum metal mirrors, but with indifferent success. The exact composition of speculum metal had long been a trade secret among the British and European professional makers, and With was unable to make mirrors of this material which did not tarnish almost immediately.



The author's observatory and reflector in Long Beach, California. Mounting and design seem to reflect heritage of With-Browning instrument above.

He quickly realized the great potentialities of thermally stable glass with a durable and very bright coating of silver for reflecting telescope mirrors; and he began spending all his available time in overcoming the practical optical problems of making telescope mirrors of glass. With probably never used the Foucault knife-edge test as we know it today. Probably, however, he used a modification of this test in his shops and did all his final testing of the mirror in its final stages of figure on the stars.

In less than a year, With was beginning to produce mirrors of higher quality and better definition than any professional had previously made. With's success in producing these new silvered-glass mirrors soon came to the attention of the Rev. T. W. Webb, one of England's leading amateur astronomers and famous for his invaluable work, *Celestial Objects for Common Telescopes* (soon to be republished). Webb purchased an 8½-inch mirror of 60″ focal length from With and had John Browning, the famous London instrument maker, build the equatorial mounting. Webb obtained this 8½-inch reflector just after the publication of the first edition of his famous observing book. He used his new With-Browning reflector side by side for several years with a fine 5½-inch Alvan Clark refractor, observing simultaneously thousands of double stars, clusters, nebulae, and the moon and planets. His published reports on the relative performance of the two telescopes were classics. Webb found the With-Browning reflector always far excelled the smaller Clark refractor under good "seeing" conditions.

In his day, Webb was England's accepted authority on observing and telescopic performance, and his reports and opinions carried great weight. Upon Webb's unqualified recommendation of silver-on-glass reflectors, George With soon found hundreds of dedicated and experienced English amateurs beating a path to his door. With's mirrors, mounted on both altazimuth and equatorial mountings by Browning, soon became famous. While amateur telescopic observing had flourished since the turn of the 19th century in England, all but the wealthy had confined their personal telescopes only to the very small refractors because of their great expense. Amateurs soon discovered they could purchase 8½- and 10½-inch With-Browning reflectors for less than a fine 4-inch refractor, and the light grasp and resolution of these new instruments were several times greater than a small refractor. Many reflector owners soon were resilvering

their With mirrors, finding it an interesting and educational little chemical experiment. With also found that amateurs with little money for their hobby were purchasing mirrors from him and building their own mountings.

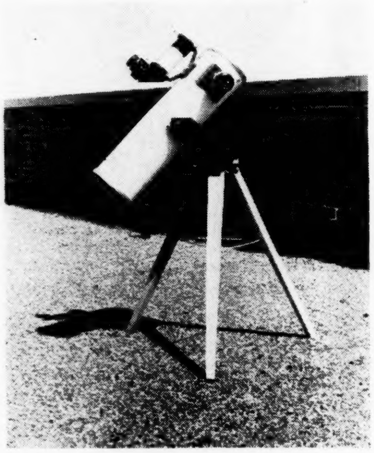
By 1866, the reflector had become known as the "poor man's telescope," a title originally bestowed upon it by the Rev. Webb. George With continued building mirrors of all apertures from 4½ to 18 inches, literally by the hundreds, for more than twenty years. His most famous telescope mirror was made in 1876 for the famous English portrait painter and amateur astronomer, N. E. Green. This mirror was a 13½-inch of 112" focal length and was mounted on a simple altazimuth mounting with slow motions by Browning. In the late summer of 1877, Green took the telescope with him to the island of Madeira and executed the most famous series of color drawings of Mars ever made, winning for him the gold medal of the Royal Astronomical Society and a name of lasting prominence in the study of Mars.

George With was constantly deluged with orders for his mirrors; often he complained of being six months behind on current orders. Even so, his spare time was still devoted to chemical experiments of a practical nature. Living in a rural farming section of England, he worked on chemical means of enriching the soil for the farmers. By the early 1880's he had developed a chemical fertilizer which, with the help of financial backers, he began manufacturing and marketing. In a few short years, he amassed a great fortune, completely gave up telescope mirror making, and devoted all of his time to his chemical company.

Thus ended the amazing optical work of one of the world's great all-time opticians. With's great skill had established the silver-on-glass Newtonian reflector for a long time to come as the primary working tool for the British amateur astronomer. His pioneering work paved the way for Dr. A. A. Common to build his 36-inch and 60-inch reflectors which were used for stellar photography—the forerunners of the great modern research reflectors at Mt. Wilson, Palomar and Lick. ●

MORE ON RICH-FIELD OBSERVING

Last issue in these columns we discussed the many advantages of low powers and the resulting wide fields of view that these minimum magnifications bring. Space limitations kept us from delving further into the pleasures of rich-field observation. The accompanying illustration shows a typical "richest-field" telescope which has been adapted for tracking faint artificial satellites.



RFT adapted to use by St. Louis Moonwatch team. Made by Cave Optical Co., this 6-inch f/4 instrument uses a special 1½" Erfle ocular and is on Edmund altazimuth mount and tripod. At 15x it gives field of 5°. Finder is actually superfluous.

Actually, it is not necessary, or even desirable, that an "RFT" be mounted, although it *is* necessary if it is to be used for Moonwatch observations. As stated previously, an RFT is an optimum combination of magnification, aperture and focal length which enables the viewer to see more Milky Way stars at one time than in any other telescope—including the 200-inch at Palomar. This is true because, beyond the 12th magnitude or thereabouts—the limit of a 6-inch telescope—the increase in numbers of stars drops off. Although a bigger telescope will show fainter stars, it will not show as many. (A more detailed discussion of this may be found in *Amateur Telescope Making—Advanced*, edited by Albert Ingalls. It is available in many libraries and bookstores.)

Ideally, an RFT is cradled in the arms and used from a sitting position. A typical instrument gives a magnification of about 21x, has an aperture of 6 inches, and a focal length of 24" (f/4). This gives a field of view as wide as five full moons—and, incidentally, the view of just *one* full moon in an RFT is nearly blinding. The telescope merely follows the inclinations of your eye; an object of interest at the edge of the field is quickly brought into the center for a closer inspection. By using this technique, the observer is never conscious of the slight distortion of the star images at the edge of the field, an aberration inherent in any short-focus mirror system such as this.

The RFT is not a jack-of-all-trades, although the writer has made a number of observations with it at higher powers. Stuart L. O'Byrne, a contributor to the SKY MAP, has used a mounted RFT for many years for lunar and planetary observations, but this is pushing the little instrument out of its depth. Aside from the field distortion of such a short-focus telescope, the large size of the flat diagonal mirror, required to utilize the full field of the low-power eyepiece, causes interference effects which limit the accurate definition of small lunar or planetary details and the resolution of close double stars.

As a second telescope, however, the RFT carries our highest recommendations, especially for the fortunate fellow who has clear dark skies in his own backyard. The 4½-inch RFT described and pictured in the July-August issue was assembled by its owner, who made the mirror himself. An f/4 mirror is not a project for a beginning mirror-maker, however, because the deep parabola of the mirror's figure demands high accuracy. Such a mirror can be purchased from professional suppliers, however. The Megginson 4¼-inch was assembled from parts sold by the Adler Planetarium in Chicago, including a combination eye-piece holder and large diagonal mirror, an aluminum tube, a cell to contain the finished mirror, and a 1¼-inch eyepiece. The cost, including the mirror-making kit, was less than $50.00.

Only one RFT is available commercially as a stock item, and it is similar in design to the mounted 6-inch RFT in the accompanying photo-

(Continued on page 24)

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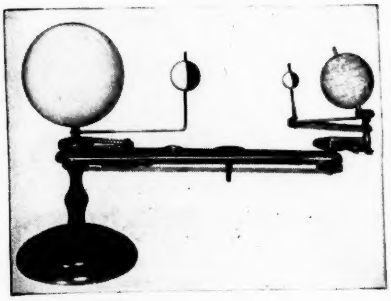

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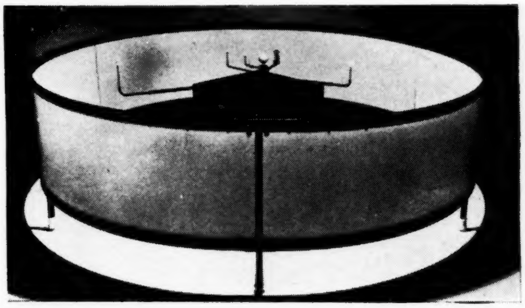

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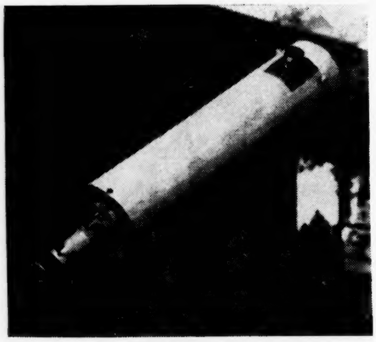
graph. It consists of a tube, mirror, a large flat and flat-support, an eyepiece and a focusing adapter. It is manufactured by the Cave Optical Co. of Long Beach, Calif., and sells for about $125. However, there are a number of optical suppliers who would be able to make such a mirror for you. The SKY MAP will furnish such a list, including sources of other components, to anyone inquiring.

An alternate to a reflector-type RFT would be a short-focus refractor of about 3-inch aperture and 18″ focal length. With a wide-field Erfle eyepiece this combination would give a magnification of 12-15x and a field of 4-5°. While this would not be a true "richest-field" telescope, the view would certainly be spectacular. Lenses and components for such a telescope may be obtained from A. Jaegers, 691 Merrick Rd., Lynbrook, N. Y.

A word of warning to RFT users! An RFT is designed to be viewed with a fully dark-adapted eye. In twilight skies, or with a pupil that is still adjusting to the darkness, an RFT will not function efficiently. The "pencil" of light leaving the eyepiece will be larger than the pupil opening, and will be "vignetted" or cut off by the incompletely distended pupil. Additionally, the dark outline of the extra-sized flat mirror (in reflectors) will be noticeable and annoying. The RFT is strictly a dark-sky instrument.

Some people want the best of both worlds . . . a few manage to attain it. In connection with this matter, we have a letter from Jack Eastman, Jr., of Manhattan Beach, Calif., who is a member of the Los Angeles Astronomical Society. We excerpt the letter as follows:

"I read with interest your column "Through the Three-Inch." I am primarily interested in lunar and planetary photography, but a couple of years ago I thought it would be nice to have a richest-field telescope. At the time I was building a 4½-inch Cassegrain with a primary of 17″ focal length. When the Cassegrain focus (f/20) didn't live up to expectations, I fixed up the instrument as an f/4 Newtonian. With a 16.8mm ocular, it gives 25 power and a 3° field; with a 28mm ocular, I get about a 4½° field, but the higher power gives more desirable results. This telescope can easily be hand-held or mounted on the equatorial mount. Recently I came across a good Cassegrain secondary mirror and, since the primary had been perforated, I decided to set up the instrument as a combination Cassegrain-Newtonian.



"The long and the short of it," a combination "Newt-Cass" by Jack Eastman of Los Angeles.

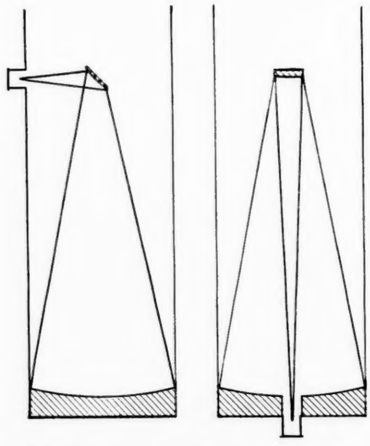
"The Cassegrain focus is f/15 and works very well up to about 200 power. I was most amazed at the performance of this instrument, since the secondary was given to me by a friend and had not been matched up with the primary. The portability of this instrument is much to be desired, to say nothing of the rich field at the Newtonian focus.

"I think if anyone wants a good, versatile, easily portable telescope, nothing beats a combination Cassegrain-Newtonian if it is well made and properly lined up."

Mr. Eastman's double-duty reflector has much to recommend it. This combination, and the focal lengths cited, are common in many larger observatory telescopes, but they are not in regular use among amateurs. His instrument comes close to being that "all-around" telescope, the quest for which has sent many an amateur howling into the night.

For the benefit of our readers who may not be familiar with the difference between Cassegrain and Newtonian reflecting telescopes, we have included comparative schematic drawings. A special feature of a Cassegrain mirror system is that it allows the use of a long effective focal length (f/20, for example) and the resulting advantages — minimized coma and off-axis distortions and high magnifications with ordinary eyepieces, to name a few—without the mounting and tube-length problems inherent in a telescope 20 times longer than its diameter.

The standard Cassegrain, as the diagram shows, has a main mirror (primary) which is perforated in the center. Light entering the tube is reflected by the primary to a secondary mirror which is, instead of a prism or flat mirror as in the Newtonian type, a convex mirror of hyperbolic figure. In effect, this convex secondary figurately "speeds" the converging light rays to a focus through the hole in the primary mirror, where an eyepiece is used to magnify the image. Thus, in the case of Mr. Eastman's telescope, the tube is less than two feet long, whereas, in the case of a Newtonian telescope of similar focal length (f/15), the overall tube-length would have to be more than five feet.



Short - focus Newtonian (left) uses deep paraboloidal mirror to bring rays to flat secondary. Eyepiece at left magnifies image. Cassegrain (right) has perforated primary mirror which receives image from hyperbolic convex secondary mirror.

Then, by substituting a flat diagonal secondary mirror for the convex mirror, the instrument is quickly modified into a short-focus (f/4) system and the image is viewed from the side of the tube in the usual manner. However, it must be mentioned that, as in the case of the ordinary RFT, the deep, short-focus parabola is not a project for the amateur's first efforts. Tolerances for error are much lower than in the f/8-f/12 focal ratios (diameter to focal length) commonly adopted by the novice.

The primary use for Cassegrain telescopes is in planetary observing. The Cassegrain system has a very small field of view, quite satisfactory for its intended purpose when used

with a clock-driven equatorial mounting but hardly an instrument for observing loose star clusters or rich star fields in the Milky Way. Because the two systems are diametrically opposed as to purpose, their combination in one telescope has many advantages. We thank Mr. Eastman for bringing his instrument to our attention.

THE TELESCOPE MART

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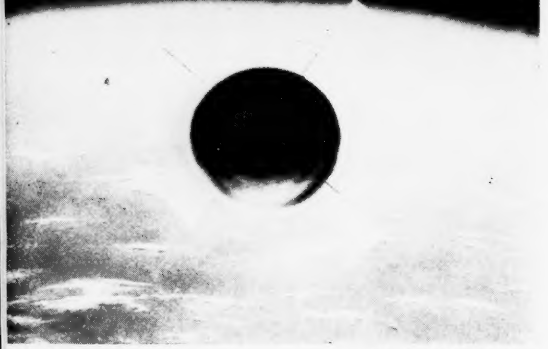

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IN THE MOONWATCH ORBIT . . .

By Leon Campbell, Jr.

WHEN the first satellites were orbited, most Moonwatch teams were prepared to observe them with small, simple telescopes. These were mainly the so-called Moonwatch monoculars of very short focal length—50mm objectives, about 5.5 power, with Erfle eyepieces. They were certainly good enough for the observations of the Russian sputniks, which were of naked-eye magnitude.

Then along came the fainter satellites with magnitudes of 7th or 8th at perigee, and the monoscope was simply incapable of acquiring these objects. However, a number of Moonwatch teams had the war-surplus M-17 elbow telescope available, an instrument of short focal length, 50mm objective, 6 power, with wide-angle eyepiece. These instruments are superior for the purpose of the Moonwatch monoscope, and capable of acquiring objects as faint as at least 9th magnitude. A few stations had modified versions of the M-17 with a 120mm objective, which were capable of penetration down to 11th magnitude, and possibly fainter. Stations fortunate enough to have the M-17 and the modified version on hand were able to observe most of the fainter satellites, but these few stations could not produce all the observations needed.

As time went on, the number of launchings of truly faint satellites continued to increase. One by one, Moonwatch stations acquired deeper-penetration telescopes of nearly every conceivable type, and made more and more observations. These instruments possessed relatively small fields of view, often less than one degree, but they were capable of sighting objects down to 13th magnitude. (Indeed, even the "grapefruit-size Vanguard satellite — 1958 Beta — didn't escape observation by several Moonwatchers!)

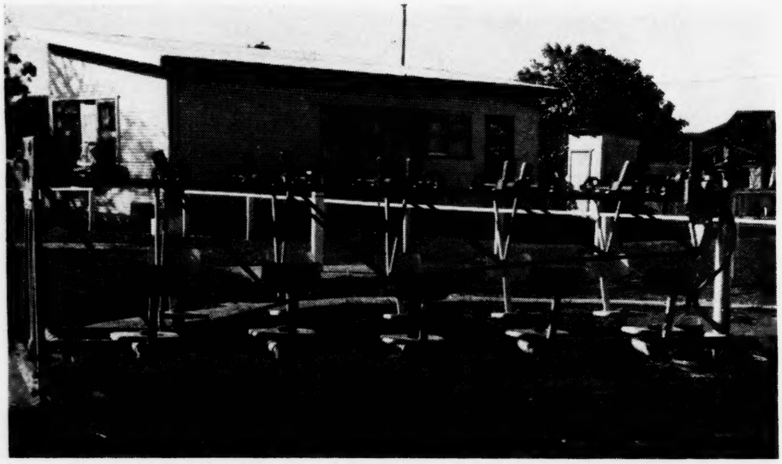
One of the benefits of these small-field, deep-penetration telescopes was that it allowed the observer to make extremely accurate measures of satellite positions, since the small field reduced the limits within which the measures were to be made. Some instruments pressed into use constituted theodolites whose circles are read photographically at intervals, and thus permit extremely accurate readings in altitude and azimuth.

To use these small-field telescopes, however, required that the predicted positions of the satellite should be accurate. Several satellites were placed in stable orbits and behaved as expected, and their positions thus were accurately predicted. Only good computing of which many a Moonwatch team is capable was required to "put the satellite right through the center of the field."

In recent months the Smithsonian Observatory, from which the Moonwatch Program is directed, has made available to more than 75 stations a number of the M-17's and to a smaller number the 20 x 120mm modified instrument. The number of observations of fainter satellites has therefore increased.

An ever-growing activity among Moonwatch teams is the hunt for lost or undiscovered satellites. Generally this search requires deeper penetration telescopes (sometimes better telescopes than the 20 x 120). The accumulation of these superior instruments by more and more stations has made it possible for teams to discover or rediscover several satellites. In the years to come there will rarely be any excuse for not finding a satellite by visual means, provided the need exists and observers are eager to persevere in the hunt.

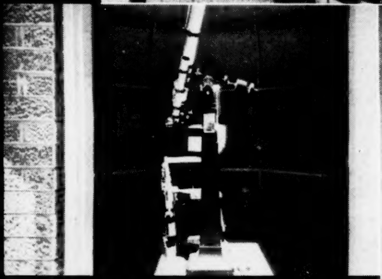
An aside—an oft-repeated question is: How is Moonwatch doing? Is there still interest among the teams? Some statistics will answer the question. Since February of this year, when the total number of satellite observations reached a near-low point (owing to weather), the trend has been upward. Observations reported during the second quarter of 1960 were the highest on record—3,099 (April, 775; May, 1,301; June, 1,023). A hint that the third quarter may equal that peak is to be seen in the July total, which reached 938 observations. [Editor's note: *Launching of the Echo I balloon satellite Aug. 12th should swell third quarter totals. The satellite was bright and well placed for observation during the latter half of August.*]



The Sydney, Australia, Moonwatch Station uses the M-17 elbow telescopes with Ross wide-angle eyepieces. An unusual mounting system, in which all telescopes are linked together by a cable system, enables the entire line of instruments to be moved as a "fence" to any desired azimuth and altitude and still retain the pre-set overlap. Working Moonwatchers will appreciate the ingenuity and efficiency of this arrangement.
(Photo furnished by Smithsonian Astrophysical Observatory.)

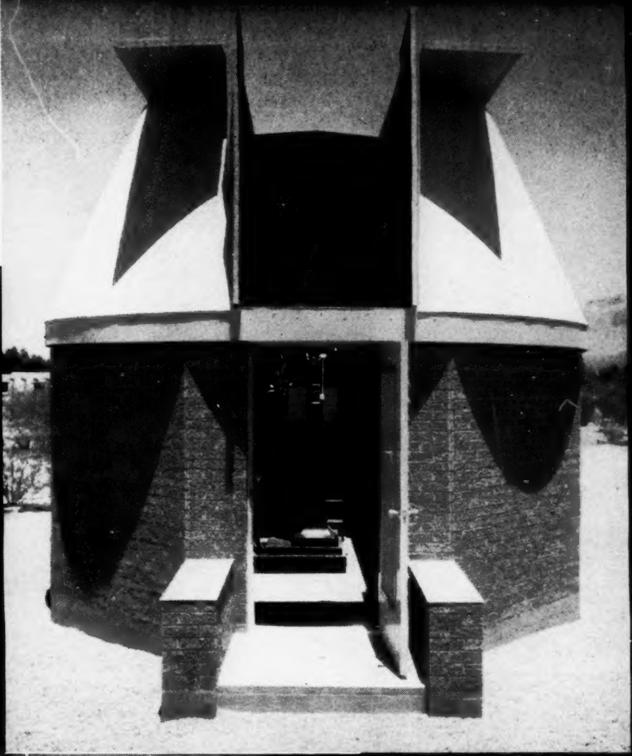
Mr. Campbell is director of the Operation Moonwatch program which is administrated by the Smithsonian Astrophysical Observatory in Cambridge, Mass.

Dome framework of Hubbard Observatory under construction. Note 15'-circular steel rail, spotwelded to 3/16" steel plate capping the octagonal wall.

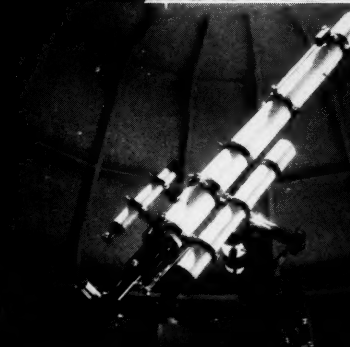


Interior view, showing adjustable observer's chair which swivels on casters around pier of 4" Model 166 UNITRON.

Bela Hubbard builds a "dream house" for his UNITRON



Exterior view. Door and windows are fitted with screens and blue glass jalousies. Dome is covered with tempered Masonite. Top shutters open outward, lie flat on domed roof. Vertical shutters open outward on hinges.



Note structural details of dome interior.

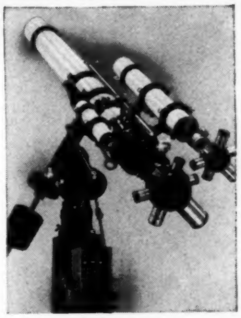
Bela Hubbard, of Tucson, Arizona, is one amateur astronomer who believes you don't have to be a millionaire to view like one.

To prove it, he built the observatory you see on this page. Presently, it houses the new 4" UNITRON Equatorial Refractor he recently bought. Eventually, it will house the 6" UNITRON he plans to own some day.

From its steel-reinforced concrete foundation, to its double-thick masonry walls, to its 15'-diameter turret dome, Hubbard Observatory is clearly a labor of love — a thing of beauty and a joy practically forever. Yet the cost was surprisingly low.

After building his "dream house", Mr. Hubbard sat down and wrote us all about it. He told us how the job was planned; the problems he solved; the materials he used; how long the job took; and how much it cost for labor and materials.

Now, we're not in the observatory business. But it occurred to us that a lot of amateur astronomers might be interested in Mr. Hubbard's "how-to" report. So with his permission, we've had the complete, illustrated report printed up as a guide and idea-source you could adapt to your own needs and equipment. Feel free to send for a copy. Also available, free, UNITRON'S Observer's Guide and Catalog. Just write:



4" Photo Equatorial — this is the UNITRON Model 166 presently housed in the observatory. With fixed pier, clock drive and astro-camera, $1280.

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